NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation
Biological Opinion

Agency:	National Marine Fisheries Service
Activity:	Biological Opinion on the Greater Atlantic Region, Protected Resources Division, proposal to issue an Incidental Take Permit for Atlantic sturgeon affected by Dominion's operation of the Chesterfield Power Station, Virginia, including completion of Clean Water Act 316(b) studies for the facility
Conducted by:	National Marine Fisheries Service Greater Atlantic Regional Fisheries Office
Consultation Tracking Number:	GARFO-2017-00728
Date Issued:	November 10, 2020
Approved by:	

This page left blank intentionally

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued pursuant to section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the effects of the proposal by NMFS to issue an incidental take permit (ITP) and approve a Habitat Conservation Plan (Conservation Plan). The permit would authorize the capture and killing of Atlantic sturgeon belonging to the Chesapeake Bay Distinct Population Segment (DPS) incidental to operation of cooling water intake at Dominion's Chesterfield Power Station (CPS), and completion of Clean Water Act (CWA) 316(b) studies for the facility.

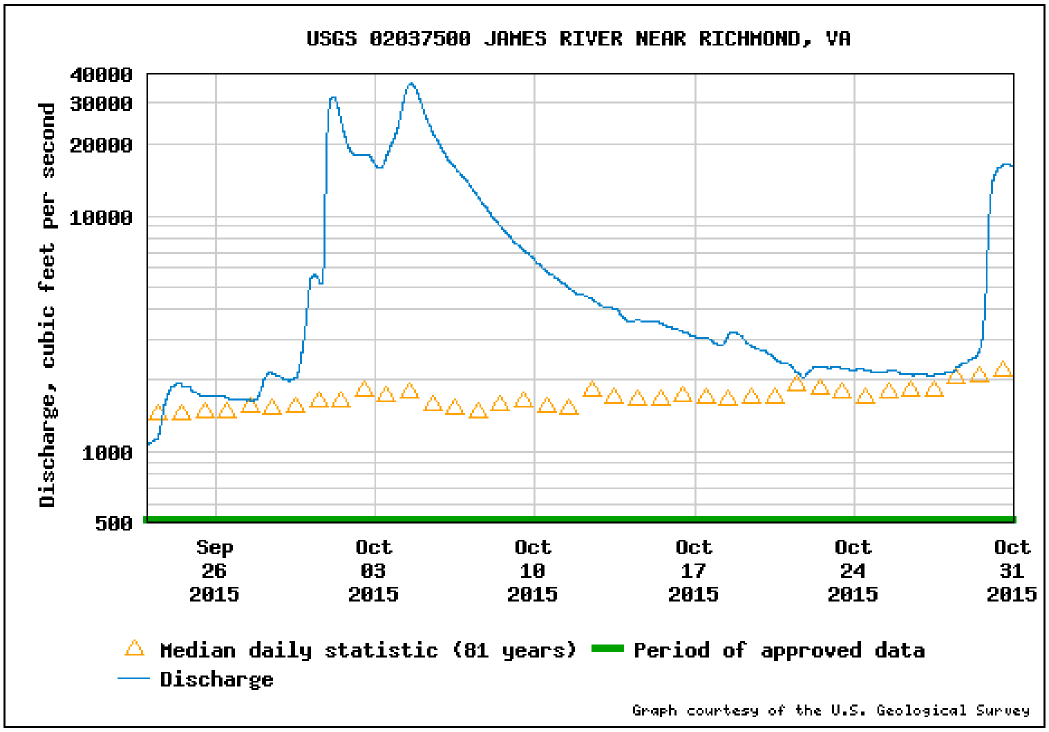
Atlantic sturgeon that originate from U.S. rivers are listed under the ESA and take is prohibited by the ESA. However, exceptions to the taking prohibitions can be made by permit. In accordance with section 10 of the ESA, individuals or groups can apply for an ESA section 10(a)(1)(B) permit (also known as an ITP) to authorize the take of endangered or threatened species, otherwise prohibited by the ESA. NMFS can issue an ITP if the taking is incidental to and not the purpose of carrying out of an otherwise lawful activity and the permit applicant submits and commits to implement a Conservation Plan that NMFS determines will monitor, minimize, and mitigate the impacts of the take to the maximum extent practicable (50 CFR § 222.307). To issue an ITP, NMFS must also find that the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild.

This Opinion serves as the finding for whether the incidental taking of Atlantic sturgeon at CPS as proposed for authorization under the ITP over the next five years will appreciably reduce the likelihood of the survival and recovery of the Chesapeake Bay DPS of Atlantic sturgeon and consideration of whether the proposed action will result in the destruction or adverse modification of critical habitat designated for the DPS. It is based on our review of Dominion's Incidental Take Permit Application, the Conservation Plan, the draft Environmental Assessment (EA), the Atlantic sturgeon ESA-listing documents, scientific and technical reports from government agencies and the peer reviewed literature, and other sources or information cited herein that together represent the best available scientific information. A complete administrative record of this consultation will be kept at our NMFS Greater Atlantic Regional Fisheries Office.

2.0 BACKGROUND AND CONSULTATION HISTORY

Dominion's CPS is located along the tidal freshwater reach of the James River, Virginia. The CPS, which began operating in 1945 is a coal-fired power station that requires cooling water for plant operations. The cooling water is withdrawn from the James River through cooling water intake structures (CWIS). On October 3, 2015, during a high-flow event (Figure 1), an adult-sized Atlantic sturgeon was impinged on a trash rack at CPS. The fish was injured, but alive when discovered, and was immediately released into the river. In January 2016, Dominion notified NMFS that newly analyzed preserved entrainment samples collected at CPS for CWA 316(b) studies on October 7 and October 8, 2015, were each found to contain a yolk-sac Atlantic sturgeon larvae[1] (i.e., an Atlantic sturgeon larvae that was still nourished by its yolk-sac). The October 7 and 8 collection dates followed reported high water events in the James River (see Figure 1).

Figure 1. Discharge for the James River from September 23 to October 5, 2015, measured at the Richmond-Westham gauge. https://waterdata.usgs.gov/nwis



Sampling continued until March 2, 2016; these were the only Atlantic sturgeon collected in the 2015-2016 sampling.

In reaction to the impingement of the adult sturgeon and the collection of the two sturgeon larvae, Dominion began discussions with NMFS about obtaining take authorization through a potential ITP. Dominion submitted a draft ITP application and Conservation Plan to NMFS on December 8, 2016. A revised application and Conservation Plan was submitted on April 7, 2017. NMFS confirmed with Dominion on May 4, 2017, that their application was complete. In July 2017, NMFS issued a Draft EA on Dominion's proposed ITP. On August 14, 2017, NMFS

[1] *Larvae* as used here refers to Atlantic sturgeon that are less than 41 days post-hatching, with total lengths (TL) less than 37 mm (Bath et al. 1981).

announced in the *Federal Register* the availability of Dominion's ITP application and draft conservation plan, as well as NMFS draft EA, for public review and comment (82 FR 37849).

In a letter dated April 20, 2018, NMFS advised that sturgeon larvae were unlikely to occur near CPS in the spring and early summer. Following receipt of this letter, Dominion resumed and completed the required spring entrainment sampling with no observations of sturgeon. In September 2018, four adult Atlantic sturgeon were impinged on intake guards[2] at CPS. In October 2018, age-0 juvenile Atlantic sturgeon, also known as young-of-year, were captured by researchers downriver of CPS. The best available information indicates that adult Atlantic sturgeon spawn upriver of CPS in the fall (Balazik *et al.* 2012a, Greenlee *et al.* 2017). Therefore, the capture of young-of year below CPS suggested that these offspring move downriver, past CPS, within weeks of hatching which would potentially make them susceptible to entrainment at CPS as they pass the facility's CWIS. These young sturgeon are considered larvae during this life stage.

NMFS received public comment on Dominion's estimated take by entrainment for their 2017 ITP application, and there was further correspondence between NMFS and Dominion regarding how best to predict future take. In September 2019, Dominion resubmitted their revised application and draft Conservation Plan to NMFS. These documents were revised in response to the public comments and the new information for Atlantic sturgeon received since the 2017 application. In response to the 2018 impingement event, Dominion completed a survey of the intake guards, repaired those that were degraded, and replaced a missing guard. Grid openings of the guards were reduced to prevent adult Atlantic sturgeon in the James River from entering the intake structure. In addition, the intake opening for each of two of the intake units was expanded to reduce water velocity. Following the capture of young-of-year Atlantic sturgeon downriver of CPS in Fall 2108, Dominion developed a revised incidental take estimate which accounts for new information that became available since the 2017 application (i.e. updated population estimates, timing and location of the Fall spawn, duration of the Fall spawn, and operation of the generating units at CPS).

NMFS issued a public notice regarding the revised proposed permit on June 17, 2020 (85 FR 36563). Dominion's current ITP application requests incidental take authorization of 54,747 sturgeon larvae over a 5-year period. Dominion has not requested incidental take authorization from any other source (e.g., impingement) or any other life stage. This consultation considers the effects of this proposed authorization and approval of an associated conservation plan.

3.0 DESCRIPTION OF THE PROPOSED ACTION

The proposed Federal action is the issuance of an individual ITP and approval of a Conservation Plan to monitor, minimize, and mitigate, to the maximum extent practicable, impacts of incidental take of endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) from the

[2] As river water is drawn towards the intakes, it must first pass the intake guards. Intake guards are bolted on the sheet walls in front of the intake screens and designed to prevent debris and organisms from entering the intake structure (Figure 1, Dominion's revised application).

Chesapeake Bay DPS as a result of cooling water intake system (CWIS) operations at CPS, and completion of CWA 316(b) studies for the facility. CWIS operations and CWA 316(b) studies at CPS can result in the unintentional take of larval Atlantic sturgeon belonging to the Chesapeake Bay DPS as a result of entrainment when the CWIS is in operation. The incidental capture of larval Atlantic sturgeon is also anticipated during fall sampling collections required to complete their CWA section 316(b) studies. Based on the information available to NMFS, Dominion's operation of the CPS and conduct of the required 316(b) sampling is an otherwise lawful activity. NMFS is authorized to issue incidental take permits under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq*.), and its implementing regulations 50 CFR § 203.307, provided, among other things, an applicant submits and commits to implement a Conservation Plan that NMFS determines will monitor, minimize, and mitigate the impacts of the take to the maximum extent practicable.

As detailed below, NMFS proposes to issue an ITP to Dominion that authorizes the following incidental take of Atlantic sturgeon from the Chesapeake Bay DPS: one larvae in the course of completing fall entrainment sampling for required CWA 316(b) studies and a total of 54,746 larvae at a rate of an average of 10,949 (range 1,820 – 33,789 per year). The permit would expire five years after the date of issuance. The proposed permit will require compliance with a number of measures designed to minimize, monitor, and mitigate the incidental take as summarized below. Information regarding the operation of CPS, discussed below, was obtained from Dominion's 2017 ITP application/Habitat Conservation Plan (Dominion 2017) as well as the revised sections of these documents (Dominion 2019). The various stressors associated with the proposed action are discussed in sections that follow.

Dominion's proposed Conservation Plan describes measures to minimize, monitor, and mitigate the incidental take of Atlantic sturgeon. Following the 2018 impingement event described above in the *Background and Consultation History* section, Dominion completed a survey of the intake guards, repaired those that were degraded, and replaced a missing guard. Grid openings of the guards were reduced to prevent the smallest adult Atlantic sturgeon in the James River from entering the intake structure. In addition, the intake opening for each of two of the intake units was expanded to reduce water velocity. The proposed action includes monitoring for impingement at the trash racks and at the traveling screens.

Dominion proposes to partner with Virginia Commonwealth University (VCU) which will provide Dominion access to VCU's tracking data for acoustically-tagged sturgeon that move upriver of CPS to spawn. In addition, Dominion will contract with VCU to deploy and maintain additional, new, receivers downstream of CPS to better inform when spawning Atlantic sturgeon (a subset of which are tagged by researchers) are in the vicinity of CPS. The information acquired about the location and timing of spawning Atlantic sturgeon is expected to help inform when sturgeon larvae may be present in the vicinity of CPS. The information can be used by Dominion for timing its remaining sampling to complete the required CWA 316(b) studies. Knowing when spawning adults move past CPS or how long they are present in the vicinity of CPS will provide information necessary to better assess the risk of CPS operations (e.g., intake flows), and to develop site-specific management actions to minimize take of larvae which could be floating downstream after spawning (e.g., planning and implementing routine maintenance outages, when practicable, to coincide with peak spawning movements).

Dominion is also proposing to implement a pilot study that tests a new approach for identifying and counting Atlantic sturgeon larvae at CPS. If effective, this approach would provide information to inform minimization measures for Atlantic sturgeon larvae.

Additional details on the operation of CPS as described by Dominion under the terms of the revised ITP and Conservation Plan documents are summarized in the following sections.

3.1 CPS Operations

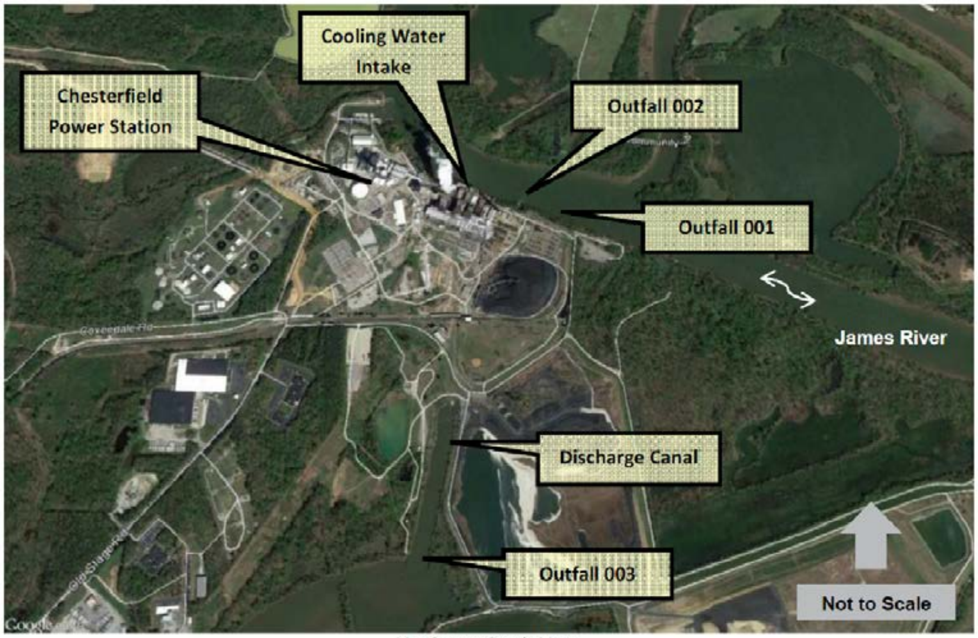
The CPS, which began its commercial operation in 1945, is located in the upper tidal portion of the James River at river mile 82 (rkm 132), approximately 13 miles (20.9 km) downstream of the fall line in the city of Richmond. CPS is authorized to withdraw water from the James River, Virginia and discharge water to the river under VPDES Permit, Number VA0004146, issued October 1, 2016. The VPDES permit is one of several required state and federal authorizations held by Dominion for the operation of CPS. The VPDES permit program is authorized under the CWA, and requires all point source discharges of pollutants to waters of the United States to obtain a National Pollutant Discharge Elimination System (NPDES) permit 33 U.S.C. § 1342. Virginia Department of Environmental Quality (VDEQ) is the NPDES permitting authority for the Commonwealth of Virginia.

CPS consists of four power-generating units: two coal-fired units (Units 5 and 6) and two natural gas/distillate oil-fired combined cycle units (Units 7 and 8) (Figure 2). Units 7 and 8 occupy the sites of the former Units 1 and 2, which were retired in 1981, after 37 and 33 years of service, respectively. After Dominion's 2017 ITP application submittal, Units 3 and 4 were retired and the mode of operation for CPS transitioned from base load operation to operating Units 5 and 6 at varying load levels in response to changes in system load requirements, while Units 7 and 8 remain base loaded. Despite Unit 4's retirement, Dominion plans to run pumps intermittently as necessary to comply with the VPDES permit (Dominion 2019). The CPS facility generally operates on a twenty-four hour per day, seven days per week basis, although there is seasonal variation in its operations and maintenance. In the summer months, all pumps are in operation to meet thermal transfer requirements.

3.2 Cooling Water Intake Operations

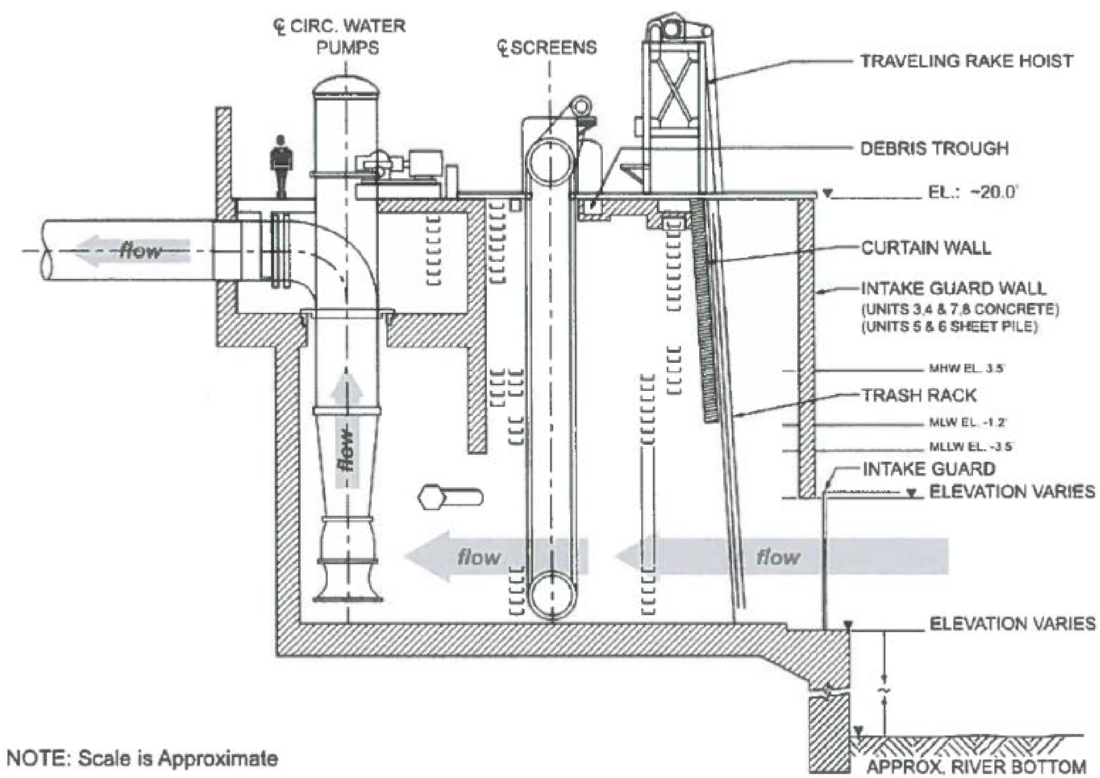
The power-generating units at CPS utilize a once-through cooling water system that withdraws water from the James River through CWISs (Figure 2). CPS has a design intake flow of approximately 1,090 million gallons per day (MGD), of which at least 25% is used exclusively for cooling purposes. The intake pipes associated with the CWISs are constantly submerged and aligned flush with and parallel to the south shoreline. CPS intake structures are designed to operate at river levels ranging from 3.5 feet below mean sea level (MSL) to 19.0 feet above MSL. The mean high and low water levels differ by approximately 5.2 feet with the mean high water mark at 3.5 feet above MSL while the mean low water mark is 1.7 feet below MSL (Figure 3)(Dominion 2016a).

Figure 2. Aerial Photograph of Chesterfield Power Station



Map Source: Google Maps

Figure 3. Typical Profile of Chesterfield Power Station Intake Structure Figure



Dominion used conservative assumptions (e.g. no ambient velocity and low water depth) to calculate the potential area of hydraulic influence of the CPS CWIS. The CWIS area of influence (AOI) represents a zone of hydraulic influence on the movement of motile, non-motile and limited mobility life stages of fish and shellfish. Based on the assumption that the AOI represents the maximum areal extent associated with the evaluated threshold velocities of 0.5 fps, 0.3 fps and 0.1 fps, the AOI is estimated as follows (Dominion 2016c):

- The AOI based on a threshold velocity of 0.5 fps is conservatively calculated as a semicircle with a radius of 69 feet centered at the CWIS. The threshold velocity of 0.5 fps is associated with motile fishes, where it is generally assumed that fish subject to 0.5 fps and lower velocities are able to swim freely and avoid impingement. For example, the CWA §316(b) rule assumes impingement is minimized at intakes with 0.5 fps through-screen velocities.

- Ambient velocities are typically expected to predominate and therefore influence movement of non-motile and limited mobility life stages (e.g., eggs and larvae). The AOI based on a range in velocity thresholds from 3.0 cm/s (0.1 fps) to 9.1 cm/s (0.3 fps), representing these ambient velocities (e.g., at slack tide or under gentle breeze conditions in a lacustrine system) is calculated as a rectangular area ranging from:

    - 2,772 feet along the river axis (i.e., 1,386 feet upstream and 1,386 feet downstream from the CWIS) and 359 feet wide across the river (for comparison, the James River is approximately 500 feet wide at this location), centered at the CWIS using a velocity threshold of 0.3 fps;

    - 8,315 feet along the river axis (i.e. 4,158 feet upstream and 4,158 feet downstream from the CWIS) and extending across the river (which is approximately 500 feet wide at this location), centered at the CWIS using a velocity threshold of 0.1 fps.

As river water is drawn toward the intakes it first encounters a curtain wall that extends beyond the low water level. The curtain walls for Units 4, 7, and 8 extend to 4.5 feet below MSL while the curtain wall for Units 5 and 6 drops down to approximately 4.0 feet below MSL.

Downstream (i.e. toward the intakes) of the curtain wall are the trash racks which are installed across the intake structures in front of the screen bays. Trash racks extend across the entire length of each intake structure (i.e. from the intake structure invert to the intake deck) and prevent large debris from entering the screen houses. The trash racks for Unit 4 are approximately14.5 feet tall by 9.9 feet wide with 0.375-inch bars placed vertically on 4.0-inch centers. The Unit 5 trash rack is approximately 16.5 feet tall by 12.5 feet wide with 0.375-inch bars on 4.5-inch centers. The Unit 6 trash rack is approximately 19.0 feet high by 15.0 feet wide with 0.375-inch bars on 4.0- inch centers. Units 7 and 8 have trash racks that are approximately 14.5 feet high by 11.0 feet wide with 0.375-inch bars on 3.0-inch centers (Dominion 2017). Dominion’s calculations for the through-rack (or through-screen) velocities for the intake guards, trash racks, and traveling screens for each intake are summarized in Table 1. The traveling water screens located 10-20 feet inside of the trash racks have 3/8 inch (9.5 mm) mesh. Dominion projects that future operations at the CPS facility would continue to withdraw water at approximately 60 percent of the Design Intake Flow (DIF) based on intake operations at the four remaining generating units at CPS (Table 2).

	Water Velocities in fps based on Design Intake Flow				
Intake Structure	**Unit 4**	**Unit 5**	**Unit 6**	**Unit 7**	**Unit 8**
Approach to	0.79	0.84	1.01	0.74	0.67
Intake guards	1.07	1.12	1.35	0.85	0.88
Trash racks	0.51 – 1.13				
Traveling screens*	1.19	1.53	1.99	1.30	1.30

*Assumed open area of 67.9 percent for a 3/8-inch mesh traveling screen

Table 1. Summary of Through-rack Velocities for Intake Guards, Trash Racks, and Traveling Screens at Chesterfield Power Station

Unit	Daily Flow (m^3)	Total Volume of Water Withdrawal (m^3)
Unit 4*	98,705	4,145,610
Unit 5	395,197	16,598,274
Unit 6	817,649	34,341,258
Unit 7	328,574	13,800,108
Unit 8	328,574	13,800,108

*As reported by Dominion, Unit 4 has been retired for power generation however; pumps will be run intermittently as necessary to comply with Virginia Pollutant Discharge Elimination System Permit No. VA00004146. One of two pumps at Unit 4 is included at 50% of DIF to provide a conservative estimate of incidental take.

Table 2. Summary of Volume of Water Withdrawal based on approximately 60 percent of the Design Intake Flows at Chesterfield Power Station during a six-week period in September-October

To prevent organic buildup and biofouling in the cooling water system, sodium hypochlorite is used for chlorination of the cooling water system and sodium bisulfite is used for dechlorination. Residual chlorine levels are maintained in accordance with the VPDES permit.

3.3 Required Clean Water Act 316(b) Studies

The purpose of CWA 316(b) sampling is to characterize entrainment and impingement associated with CPS operations. The 316(b) entrainment sampling program, which would resume as appropriate following the issuance of the ITP, is summarized in Table 3. In order to complete the two-year, 316(b) sampling program, samples will be collected at near-bottom depths during September through December 2020. Bottom samples during September and October have the potential to entrain Atlantic sturgeon larvae. Therefore, Dominion's current ITP application requests incidental take for Atlantic sturgeon larvae from the Chesapeake Bay DPS. The proposed permit would authorize the incidental take of no more than one Atlantic sturgeon larvae in water samples needed to complete the required CWA 316(b) studies.

Entrainment	Details
Units to be sampled	Unit 6 (Primary Location) and Unit 4 (Secondary Location)
Sampling Events	Twice per month sampling events (within the first and third week of each month) for 2 months (2/month x 2 months = 4 sampling events)
Daily Collection Schedule	Samples collected every 6 hours in a 24-hr period (4 collections/24-hr period)
Targeted Organisms	Fish eggs, larvae, and juveniles; shellfish life stages
Depths	Near-bottom depth only
Number of Samples Collected per Depth	1 sample collected by pumping water through a 335-µm net suspended in a buffering tank (Three sub-samples for each depth will be combined)
Sample Duration	~100 minutes per depth per 6-hour sample (or time required to get 100 m^3 per depth per 6 hour sample)
Number of Samples per Sampling Event	4 collections/survey x 1 depth/collection x 1 sample/depth = 4 samples/survey
Total Number of Samples Remaining	4 samples/survey x 2 surveys/month x 2 months = 16 samples

Table 3. Details of Remaining 316(b) Entrainment Sampling during Fall Spawning Period

Impingement samples will be collected from the fish/debris return troughs which extend from the east end of the intake structures from an origin inside the last screen and will not include any in-river sampling but rather just document impingement that occurs as a part of normal operations.

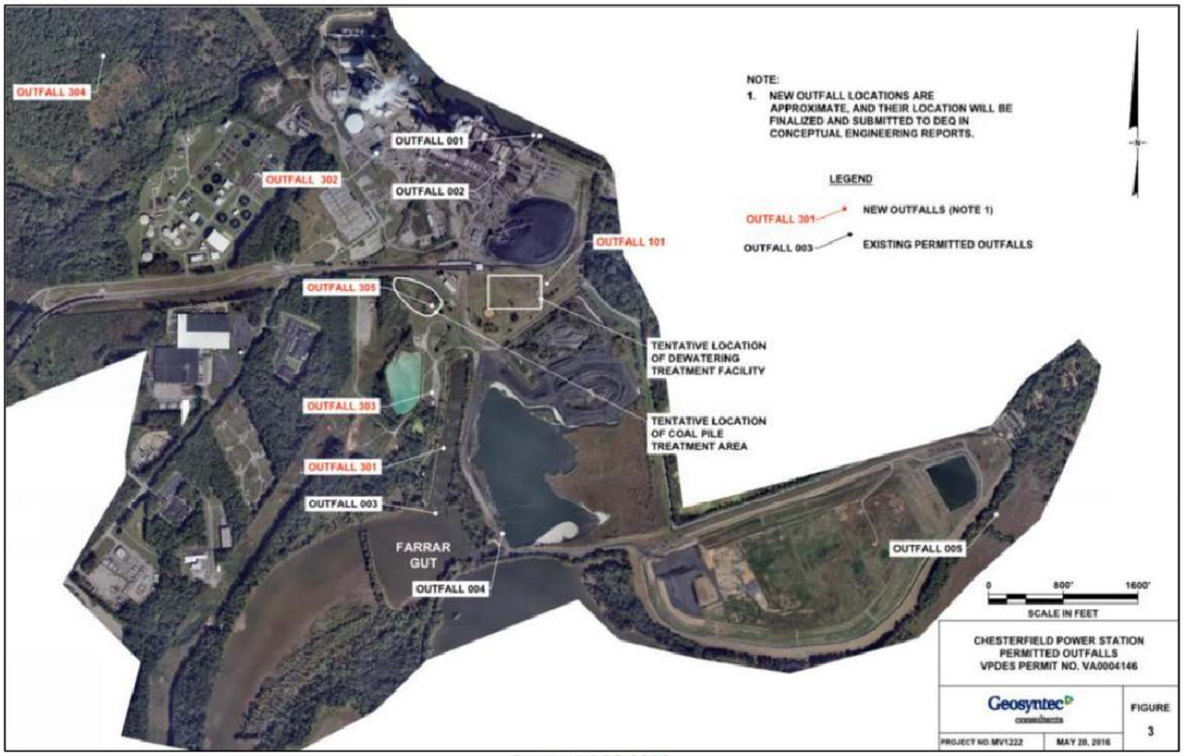
3.4 Other Activities Associated with CPS Operations

Dominion does not anticipate and is not requesting take of Atlantic sturgeon at CPS from any other activity including dredging, constituent discharge, thermal discharge, vessel movements, or shoreline and structural maintenance associated with operation of CPS. NMFS proposed permit also does not include any take authorization from any of these sources. Details on each of these activities under the terms of the existing VPDES permit (VA0004146), and as proposed by Dominion in the current ITP application are summarized below.

3.4.1 Discharges

The VPDES permit regulates water discharges associated with both storm water and industrial wastewater, including discharges of once through non-contact cooling water (Figure 4).

Figure 4. Locations of Chesterfield Power Station Outfalls



Source: VDEQ 2016

3.4.1.1 Heated Effluent

Non-contact cooling water is discharged from Outfalls 001 and 003. Outfall 001 discharges effluent from Units 7 and 8 to the mainstem of the James River and Outfall 003 discharges effluent from units 4, 5, and 6 to the head of Farrar Gut (Table 4). Afeeter Dominion's 2017 ITP application submittal, Units 3 (which discharged to Outfall 002) and 4 were retired (note that Units 1 and 2 were retired in 1981). Despite retirement of Unit 4, Outfall 003 will continue to receive cooling water discharges as pumps at this unit will be run intermittently as necessary to comply with the VPDES Permit. The permit established reporting and compliance limits for discharge temperatures and heat content in millions of British Thermal Units (Btu; the British thermal unit is a unit of heat; it is defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.) associated with the operation of the once through cooling water system for CPS are regulated for CWA purposes by the terms of the VPDES permit (VA0004146). Under this permit, the maximum unit discharge temperatures from the contributing units are continuously monitored to ensure that the heat rejected does not exceed 11.3 x 10^8 Btu/hour for Outfall 001 (Units 7 and 8) and 5.55 x 10^9 Btu/hour for Outfall 003 (Units 4, 5 and 6). Based on 40 years of VDEQ sampling data, annual stream temperatures recorded at monitoring station 2-JMS099.30 were below 29.3 °C 90% of the time (VDEQ 2016). Monitoring station 2-JMS099.30 is located at buoy 157 on the James River approximately 4 miles upstream of Farrar Gut. In the 2016 reissuance of the VPDES permit, the VDEQ used data from this station to represent background ambient conditions before interaction with the heated effluent from the CPS facility.

Outfall Number	Wastewater Source	Receiving Stream	90% Temperature (annual) for Receiving Stream	90% Temperature (annual) for Effluent	Flow, MGD (maximum of 30-day averages)
001	Condenser Cooling Water from Units 7 and 8	James River, Main Channel	29.3°C	45°C	212
003	Condenser Cooling Water from Units 4, 5, and 6	James River, Farrar Gut	51.7°C*	51.7°C	753

* VDEQ determined that effluent flow from Outfall 003 dominates the tidal receiving stream, Farrar Gut. Consequently, Farrar Gut was treated as a free flowing stream with Outfall 003 being the head of the stream. Ambient flows of zero were used as a conservative assumption (VDEQ 2016).

Table 4. Heated Effluent Characterization (VDEQ 2016)

CPS conducted a CWA 316(a) demonstration study (VEPCO 2000) with field surveys conducted from 1997 through 1999. The purpose of the 316(a) demonstration study was to provide an assessment of thermal discharges at CPS on the aquatic biological community in the James River near the power station. The study analyzed water quality characteristics (e.g. temperature, oxygen, nutrients) at 11 sites located upriver and downriver of the CPS discharges. Sampling locations were located in the James River mainstem and in Farrar Gut, as well as in two other oxbows downriver of Farrar Gut (Turkey Island and Jones Neck). Sampling locations represented the thermal mixing zone (i.e., the portion of the river where initial dilution of a discharge takes place) as well as ambient conditions (i.e., sampling locations not affected by the discharge of heat). Results of the study demonstrated the presence and reach of heated effluent in the mainstem of the James River at Outfall 001 and in the upper end of Farrar Gut at Outfall 003. On both incoming and outgoing tides, surface water temperatures increased as water approached and moved past Outfall 001. At the sampling location between Outfall 001 and Farrar Gut, water temperatures increased an average of 2°C above ambient water temperatures on the slack before ebb tide. On the slack before flood tide, water temperatures were an average of 1.7°C above ambient water temperatures. As the flow of water continues past Farrar Gut, thermal effluent from Outfall 003 mixes with tidal water in the mainstem of the James River. Temperature change data illustrated that oxbows act as heat sinks, but the tidal cycle influences the thermal plume, confining it to Farrar Gut on the incoming tide and extending it downriver on the outgoing tide.

3.4.1.2 Effluent

Along with cooling water, the VPDES permit authorizes CPS to discharge wastewater via a number of outfalls directly into the James River Main Channel and indirectly to the James River through Farrar Gut. The major constituents in cooling water discharges include suspended solids, dissolved impurities, nutrients, microorganisms, and dissolved gas (Table 5). Limits on the concentration of pollutants in effluent are included when required for a specific type of facility or when a reasonable potential analysis indicates that there is a reasonable potential for an excursion from a water quality standard (then, a water quality based limit is required). The VPDES permit contains reporting and compliance limits for pollutants at each discharge (VDEQ

2016). Effluent data on discharges from Outfall 002 is extremely limited. In the absence of outfall specific effluent information for Outfall 002 following the retirement of Unit 3, the Freshwater Water Quality Criteria/Wasteload Allocation analysis (VDEQ 2016) represents the best available scientific information. It is reasonable to consider the data (e.g. 90% tile temperature and observed pollutants) as conservative estimates of the heated and polluted discharges to the mainstem of the James River.

Pollutant	**Outfall 001**	**Outfall 002**	**Outfall 003**	**Outfall 004**	**Outfall 005**
Dissolved Antimony (ug/L)				X	
Dissolved Arsenic (ug/L)				X	X
Dissolved Cadmium (ug/L)				X	
Total Chromium (ug/L)				X	
Dissolved Copper (ug/L)	X	X	X	X	
Dissolved Mercury (ug/L)	X	X	X		
Dissolved Nickel (ug/L)				X	
Total Selenium (ug/L)				X	X
Dissolved Thallium				X	X
Dissolved Zinc (ug/L)	X	X		X	
Chloroform (ug/L)	X	X	X		
Beta Particle and Photon Activity (pCi/L)	X		X		
Gross Alpha Particle Activity (pCi/L)				X	
Ammonia (ug/L)	X	X	X	X	X
Sulfate (mg/L)	X	X	X	X	X
Total Iron (mg/L)	X	X	X	X	X
Total Manganese (mg/L)	X	X	X	X	X
Chlorides (ug/L)	X	X	X	X	X
E. coli (N/CML)	X	X	X		
Tributyltin (ug/L)				X	X

Table 5. Observed Pollutants that are addressed in the Water Quality Standards (VDEQ 2016)

Dominion is currently undertaking an integrated ash project (IAP) at CPS. The IAP is a multi-year project that will eliminate the existing process wastewater discharges from the station's Lower Ash Pond (LAP) and Upper Ash Pond (UAP) and will provide additional treatment for many waste streams to reduce the concentrations of key constituents in the remaining discharges.

Currently, the LAP receives wet sluiced ash and wastewater from various sources at the facility including treated flue gas desulfurization wastewater and treated metals cleaning waste. A low volume wastewater treatment system (LVWWTS) is proposed at the facility. The LVWWTS will receive low volume wastes currently routed to the LAP. The proposed system will discharge through internal outfall 301 into the thermal discharge channel for Outfall 003.

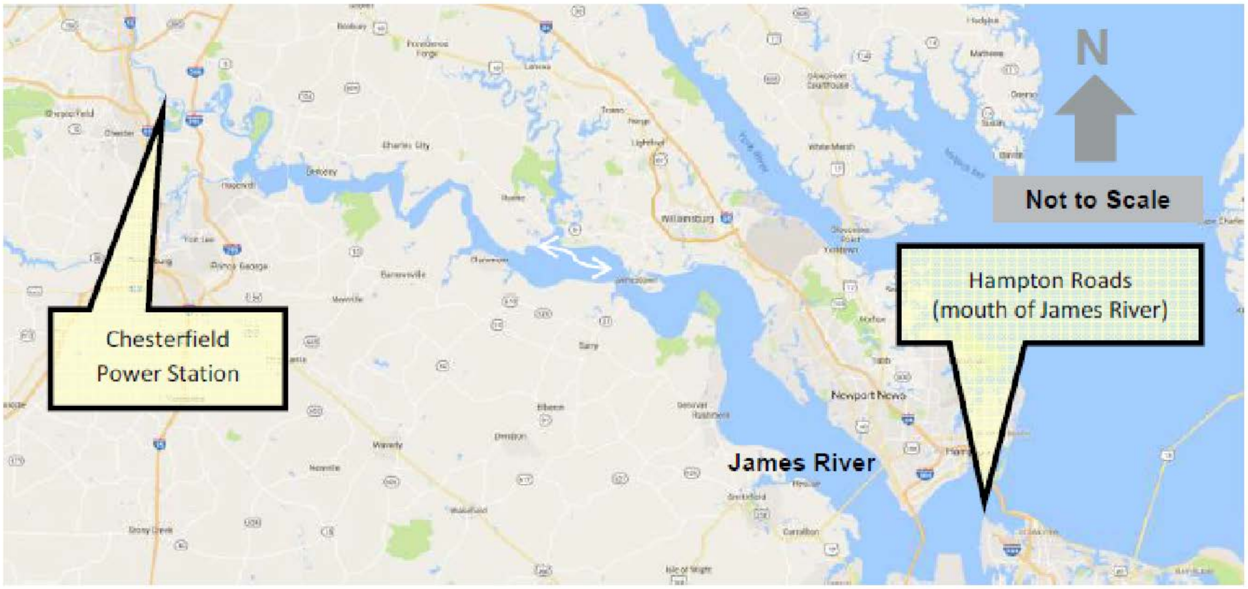
Outfall 004 is the discharge from the LAP to the head of Farrar Gut. Closure activities for the LAP include dewatering the LAP and closing in place the coal combustion residuals. Once the closure activities begin, the discharge flow rate will decrease from a 30-day average max flow of 22.42 MGD to 5 MGD. Dominion estimates that 280 million gallons of wastewater will be pumped out and dewatered from the LAP over a three-month period.

Outfall 005 is the discharge from the UAP to Farrar Gut at a point approximately 0.4 mile upstream from Farrar Gut's confluence with the James River. The UAP is used to dispose of dewatered ash from the LAP. The discharge at Outfall 005 consists of runoff from the exposed coal in the UAP that has been treated in a large sedimentation pond. The UAP closure activities are similar in nature to the LAP closure activities described above. The discharge rate during closure is estimated at 1.5 MGD. Dominion estimates that 3.5 million gallons of wastewater will be pumped out and dewatered from the UAP over a one-month period. All discharge flows during closure activities will be treated prior to discharge. During closure activities, Outfall 101 will receive effluent from the LAP and UAP, which will then discharge through Outfall 001 or 002 to the main channel of the James River.

3.4.2 Vessel Movements

CPS generally accepts 4 to 6 barge deliveries of limestone and a similar number of shipments of gypsum every month. The area of effect for vessel movements is from the offloading facility or barge slip at CPS to the mouth of the James River (Figure 5). The vessels associated with CPS are typically compact, square-bowed, and shallow draft vessels with propellers that range in width between 63 and 79 inches. A fully loaded barge would provide a minimum of 14 feet of below keel clearance during upriver transits, and a minimum of 23 feet of below keel clearance on the downriver transits. Actual clearances would generally be deeper in those reaches where shoaling is less prevalent and where the natural channel depth exceeds the project depth (Dominion 2017).

Figure 5. Location of CPS in James River



Source: Google Maps

3.4.3 Dredging

Dominion has indicated that periodic dredging is necessary to remove accumulated sediments near the CPS CWIS. Dredging occurs pursuant to permits issued by the U.S. Army Corps of Engineers (USACE) and the Commonwealth of Virginia. The permitted dredging associated with the CPS CWIS in the past has involved removing sediments using dragline dredges and the transfer of dredged material to trucks for disposal at an upland facility to prevent the sediments from re-entering the waterway. Periodic maintenance dredging is also necessary within the barge slip located northwest of CPS (Figure 6). Permitted dredging in the barge slip has generally involved hydraulic cutterhead or mechanical bucket methods with direct transfer to trucks for disposal at an existing CPS ash pond (Dominion 2003). This pond is in the process of being closed (Dominion 2017). Dredging activities are infrequent. Based on the information provided by Dominion, we do not consider them reasonably certain to occur during the permit window; this is because there are no permits currently in place for any dredging at the facility and we are not aware of any plans for dredging within the proposed five-year duration of the permit. Consequently, any future dredging activities are not considered effects of the action and are not considered in this consultation. If Dominion were to conduct dredging activities, they would require additional federal permitting and if it was determined that any such proposed dredging may affect ESA listed species or critical habitat, ESA consultation would be required.

Figure 6. Aerial Photo of Chesterfield Power Station Dredge Locations

3.4.4 Shoreline and Structural Maintenance

Shoreline and structure maintenance associated with CPS could include activities such as barge slip maintenance, and maintenance of ductwork over State-owned subaqueous land, as well as general shoreline and shoreline facilities maintenance. Potential construction means and methods include, but are not limited to, vibratory pile driving, impact pile driving, dewatering, concrete and/or riprap placements, excavation, and dredging. Shoreline and structure maintenance activities are infrequent. Based on the information provided by Dominion, we do not consider them reasonably certain to occur during the permit window; this is because Dominion has not identified any planned maintenance activities in the five-year proposed permit period. Consequently, shoreline and structure maintenance activities are not considered effects of the proposed action and are not considered in this consultation. If Dominion were to conduct shoreline and structure maintenance activities, they would require additional federal permitting; if it was determined that any such proposed activities may affect listed species or critical habitat, ESA section 7 consultation would be required.

3.5 Monitoring, Minimization and Mitigation Measures

Following the 2018 impingement event described in the *Background and Consultation History* section, Dominion revised the proposed monitoring, minimization, and mitigation measures in their Conservation Plan to further reduce the impacts of incidental take of Atlantic sturgeon as a result of CWIS operations and completion of CWA 316(b) studies at CPS. The primary components of Dominion’s Conservation Plan reflect mitigation measures taken to eliminate incidental take of Atlantic sturgeon due to impingement; to provide more specifics on the proposed measures to mitigate impacts associated with the incidental entrainment of larval Atlantic sturgeon; and to outline a proposal to implement a pilot study that tests a new approach for identifying and counting Atlantic sturgeon larvae at CPS. If effective, this approach would provide information and inform minimization measures for Atlantic sturgeon larvae.

3.5.1 Proposed Measures to Monitor for Entrainment

Over the life of the proposed five-year permit, Dominion will monitor for the entrainment of Chesapeake Bay DPS eggs, larvae, and age-0 juveniles (i.e. young-of-year) that are small enough to pass through CPS's water intake structures and debris screens. Dominion is proposing to collect water samples from intake piping installed along the front of the trash racks. The near-bottom sample will be collected approximately 3 feet above the intake bottom and the face of trash racks will be used to stabilize the temporary intake piping. A comprehensive description of entrainment monitoring protocols is available in the Conservation Plan documents (Dominion 2017).

3.5.2 Proposed Measures to Monitor for Impingement of Adults

In the time since Dominion's 2017 ITP application submission, Dominion completed a survey of the CWIS intake guards, repaired those that were degraded, and replaced a missing guard. Grid openings of the guards were reduced to prevent adult Atlantic sturgeon in the James River from entering the intake structure, with the spacing designed to prevent even the smallest adults from passing through the guards. In addition, the intake opening for each of two of the intake units was expanded to reduce water velocity.

As described in the proposed Conservation Plan, Dominion will monitor for impingement at the trash racks and at the traveling screens. Monitoring will not occur at the intake guards because it is not feasible due to the turbidity of the river and the safety risk for personnel. In the event that a living or dead sturgeon is found among the debris floating in the water or in the debris removed from the trash racks, Dominion proposes to implement a sturgeon handling plan using best management practices that include: (1) a protocol for safely removing an impinged sturgeon from the trash racks; (2) assuming any impinged sturgeon is alive unless it is obviously dead (e.g., based on visual signs of decomposition) and taking steps to safely remove the impinged sturgeon; and (3) safely returning the impinged sturgeon to the river as soon as possible. A comprehensive description of impingement monitoring protocols and the sturgeon handling plan is available in the Conservation Plan documents (Dominion 2017).

4.0 ACTION AREA

The action area is defined in 50 CFR §402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area for this consultation is the James River from 1,267 meters (4,158 feet) upriver from the CPS CWIS downriver to the mouth, as well as the Farrar Gut oxbow. CPS is located in Chesterfield, Virginia, along the upper tidal portion of the James River (river mile 82; river kilometer (rkm) 132. This is the region of the river that may be affected by the operation of CPS, which includes operation of the CWIS, constituent and thermal discharges, and vessel movements. We established the upstream distance as part of the action area based on the CWIS zone of hydraulic influence identified in Dominion 2016c (see *Cooling Water Intake Operations,* section 3.2).

Vessels associated with CPS limestone deliveries and gypsum shipments are expected to travel back and forth between the CPS offloading facility or barge slip and the mouth of the James River (Figure 5).

5.0 SPECIES AND CRITICAL HABITAT IN THE ACTION AREA

The species that may occur within the action area are listed in Table 6 along with their regulatory status and critical habitat designation; the only designated critical habitat within the action area is that of the Chesapeake Bay DPS of Atlantic sturgeon.

Marine Reptiles			
Species	**ESA Status**	**Critical Habitat**	**Recovery Plan**
Green Turtle (*Chelonia mydas*) – North Atlantic DPS	T – 81 FR 20057	63 FR 46693*	FR Not Available 10/1991 – U.S. Atlantic
Kemp's Ridley Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	-- --	03/2010 – U.S. Caribbean, Atlantic, and Gulf of Mexico 09/2011
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710* and 77 FR 4170*	10/1991– U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic Ocean DPS	T – 76 FR 58868	79 FR 39855*	74 FR 2995 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 05/1998 – U.S. Pacific 01/2009 – Northwest Atlantic

Marine Reptiles

Fish		
Species	**ESA Status**	**Critical Habitat**
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Carolina DPS	E – 77 FR 5913	82 FR 39160*
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Chesapeake Bay DPS	E – 77 FR 5879	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Chesapeake Bay DPS Critical Habitat	-- --	82 FR 39160
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Gulf of Maine DPS	T – 77 FR 5879	82 FR 39160*
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – New York Bight DPS	E – 77 FR 5879	82 FR 39160*
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – South Atlantic DPS	E – 77 FR 5913	82 FR 39160*
Shortnose Sturgeon (*Acipenser brevirostrum*)	E – 32 FR 4001	63 FR 69613 12/1998

Table 6. Endangered Species Act-listed endangered species that occur in the action area

5.1 Species and Critical Habitat Not Likely to be Adversely Affected by the Proposed Action

A “not likely to adversely affect” determination is appropriate when an effect is expected to be discountable, insignificant, or completely beneficial. As discussed in the FWS-NMFS Joint Section 7 Consultation Handbook (1998), “[b]eneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur. “Take” means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct” (ESA §3(19)). “Take” is not anticipated if an effect is beneficial, discountable, or insignificant.

Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR §402.02 and 402.17).

The effects of the proposed action are the effects of the issuance of an incidental take permit to Dominion. The proposed ITP would authorize incidental take of Chesapeake Bay DPS Atlantic sturgeon and require Dominion to implement the Conservation Plan to monitor, minimize, and mitigate, to the maximum extent practicable, impacts of the incidental taking that could occur as a result of operations at CPS, and completion of CWA 316(b) studies for the facility. Here, we consider the effects associated with the continued operation of CPS consistent with the existing VPDES permit and the proposed ITP and conservation plan. . Under the terms of the existing VPDES permit, the facility will continue to discharge effluent as a result of normal operations. Dominion has indicated that the operation of the facility is dependent on receiving deliveries of limestone and shipping out gypsum; these shipments occur several times per month by barge over water and are reasonably certain to occur over the five-year life of the proposed ITP. Dominion has also indicated that dredging of the barge berth at CPS and that shoreline maintenance activities are infrequent. Dominion has not indicated any plans to conduct dredging or shoreline maintenance during the 5-year duration of the ITP. Therefore, effects to ESA listed species and critical habitat in the action area from dredging and shoreline maintenance activities are not reasonably certain to occur and do not meet the definition of "effects of the action." As a result, these activities are not considered further in this consultation. We note that if Dominion applied for any federal permits or authorizations for any future dredging or shoreline maintenance, ESA section7 consultation would be necessary for any of those activities that may affect listed species or critical habitat.

Any effects from effluent discharges at Outfalls 002, 004, and 005 are not reasonably certain to occur as the IAP and transition in wastewater management and discharges has not been completed. Therefore, because any such effects are not reasonably certain to occur, we do not consider any theoretical impacts of future discharges (or lack thereof) at Outfalls 004 and 005 pending their decommission once drawdown of the LAP and UAP occurs.

5.1.1. Sea Turtles

As noted above (*Vessel Movements*, section 3.4.2) vessels delivering limestone and shipping gypsum from CPS every month will transit between the lower James River and CPS. The only portion of the action area that overlaps with the distribution of sea turtles is the lower James River. North Atlantic DPS green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtles arrive in the mid-Atlantic from southern overwintering areas in May and typically begin migrating southward by mid-November. Sea turtles occur in waters with salinity at or near oceanic salinity levels; as such, their presence upstream of the area near Hampton Roads and Portsmouth,Virginia (NMFS NEFSC 2012) is unlikely. The only activity associated with CPS that may affect the area where sea turtles occur is vessel traffic. Interactions between vessels and sea turtles are poorly understood; however, collisions appear to be correlated with recreational boat traffic (NRC 1990) and the speed of the vessel (Hazel *et al.* 2007; Sapp 2010). Sea turtles are thought to be able to avoid injury from slower moving vessels, since the animal has more time to maneuver and avoid the vessel (Sapp 2010). The CPS limestone deliveries and gypsum shipments are typically performed via contracted towboats.

While navigating the James River, towboats adhere to United States Coast Guard Navigation Rules and Regulations regarding vessel speed, navigation, communications, and other aspects of navigating safely within inland waterways (Dominion 2019) and travel at speeds of 1 to 7 knots. Given the slow speed of the barges and their limited co-occurrence with sea turtles, it is extremely unlikely that any project vessel will strike a sea turtle. As this is the only potential effect of the action on listed sea turtles, we conclude that the proposed action is not likely to adversely affect the ESA-listed North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle.

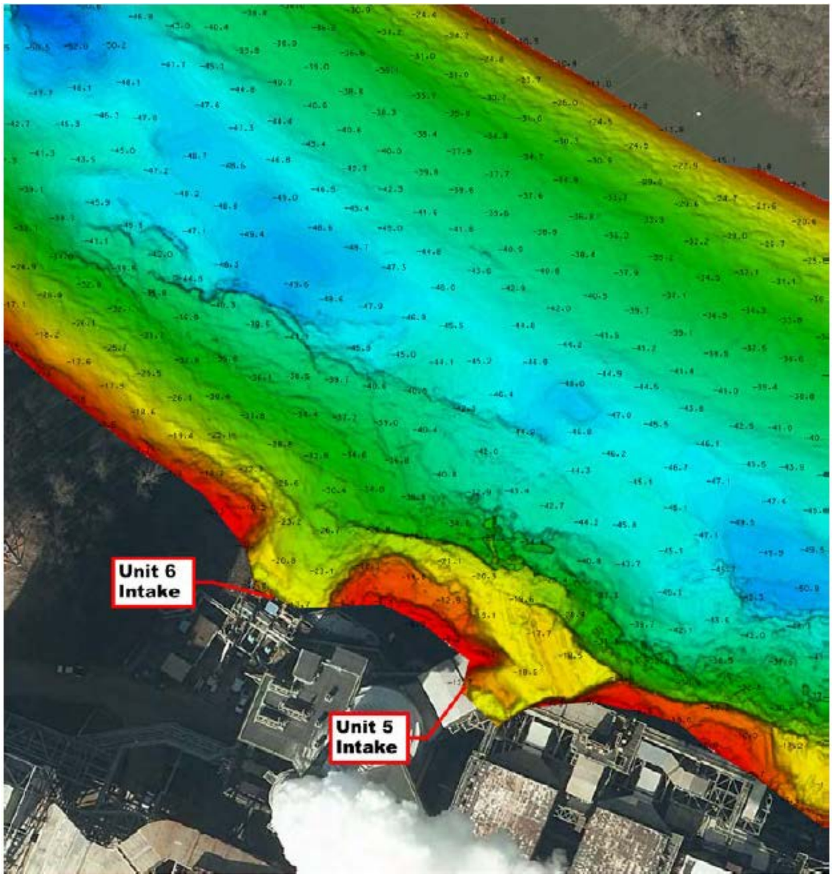
5.1.2 Endangered Species Act-Listed Fish

Carolina, Chesapeake, New York Bight, Gulf of Maine, and South Atlantic sturgeon DPSs of Atlantic sturgeon

All five DPSs of Atlantic sturgeon occur in the Chesapeake Bay and subadults and adults may at least occasionally occur in the lower James River. The only project activities that overlap with the distribution of Atlantic sturgeon from the Carolina, New York Bight, Gulf of Maine, and South Atlantic sturgeon DPSs are vessel transits. As discussed in previous sections (*Vessel Movements*, section 3.4.2), CPS generally accepts 4 to 6 barge deliveries of limestone and a similar number of shipments of gypsum every month. The vessels associated with CPS are shallow draft vessels that are slow moving (speeds of 1 to 7 knots). A fully loaded barge would provide a minimum of 14 feet (4.3 m) of below keel clearance during upriver transits, and a minimum of 23 feet (7 m) of below keel clearance on the downriver transits.

From the mouth of the James River to rkm 150, the USACE maintains the federal navigation channel to a minimum depth of 25 feet (7.6 m) and minimum width of 300 feet (91 m). Sturgeon-vessel interactions (i.e. propeller strikes) reported in Balazik *et al.* 2012c indicate that the majority of propeller strikes in the James River were caused by deep-draft ocean cargo vessels transiting through a specific 25-rkm (15.5 rm) stretch of the federal navigation channel upstream of rkm 120 (rm 74.5).This stretch is characterized by a narrow width, is maintained at the minimum navigable channel depth, and forms an area of increased propeller strike risk relative to the rest of the James River. Water depths in the navigation channel adjacent to CPS range from 25 to 50 feet (Figure 7)(USACE 2015). We expect the risk of sturgeon-vessel interactions to decline progressively with distance downriver as the below keel clearances increase and the cross-sectional profile of the river widens towards the mouth of the river; therefore, we do not expect CPS barges to interact with sturgeon as those barges transit through the stretch to delivery to CPS at RM 82.

Figure 7. Multibeam Sonar Bathymetric Survey of James River Depths in the Vicinity of Chesterfield Power Station (source Dominion 2020)



Results of Balazick *et al.* 2012c suggested that tagged Atlantic sturgeon were rarely located at the depths utilized by tugboats and small recreational crafeet in the James River between rkm 76 and rkm 131. Tracking efforts to characterize sturgeon movements of Atlantic sturgeon in the James River demonstrated that individual tagged sturgeon remain in the navigation channel or move to the adjacent shoals during the passage of commercial vessels (Reine *et al*. 2014). Similar to Balazik *et al*. (2012c), Reine *et al*. (2014) stated the tagged juvenile Atlantic sturgeon spent the majority of time in deeper waters. Based on these studies, the minimum depth of the federal navigation channel, and because CPS limestone deliveries and gypsum shipments are expected to be limited to shallow draft vessels, we conclude that Atlantic sturgeon interactions with vessels associated with CPS operations are extremely unlikely to occur. As this is the only activity that Atlantic sturgeon from the Carolina, New York Bight, Gulf of Maine, and South Atlantic sturgeon DPSs would be exposed to and effects are extremely unlikely to occur, we conclude that the proposed action is not likely to adversely affect endangered Atlantic sturgeon from the Carolina, New York Bight, Gulf of Maine, or South Atlantic DPS.

Shortnose sturgeon

We considered the information for the recent incidental capture of two shortnose sturgeon in the James River. Both of the fish were captured near rkm 48 (river mile 30), approximately 84 rkm

(52 miles) downriver of CPS. Based on its size, the shortnose sturgeon captured in March 2016 was likely an adult. Sex of this fish is unknown (Balazik 2017). The shortnose sturgeon incidentally captured in February 2018 was confirmed to be an adult female based on the presence of eggs (M. Balazik, pers. comm. to NMFS, February 2018). The similarities in the season of capture, location where captured, and life stage suggests these were not transient animals. However, their capture is also not necessarily indicative of a shortnose sturgeon spawning population in the James River because the best available information also tells us that shortnose sturgeon are still relatively rare in the Chesapeake Bay area and are likely from the Delaware River, entering through the C&D Canal into the Chesapeake Bay and its tributaries (SSSRT 2010). The presence of a shortnose sturgeon with eggs in the James River prior to any spawning season within the species range is not indicative of a spawning population in the James River because the female could travel to a known spawning river in time for the spawning season, as occurs for some females in other areas of the species range (Dionne *et al*. 2013, Wippelhauser *et al*. 2017, Altenritter *et al*. 2018). The February 2018 shortnose sturgeon was tagged in an effort to track her movements within the James River; available tagging information indicates that the individual left the James River and spawned in the spring in the Delaware River (Balazik, VCU, personal communication 2019).

Based on the best available information, we expect shortnose sturgeon to be rare visitors to the James River and to only occur in the lower river. As such, the only potential activity that would overlap with shortnose sturgeon would be barge shipments in the lower James River. Based on the same rationale presented for the Atlantic sturgeon DPSs above, we expect that it is extremely unlikely that any project vessel would interact with a shortnose sturgeon. As this is the only potential activity that may affect shortnose sturgeon and effects are extremely unlikely to occur, we conclude that the proposed action is not likely to adversely affect endangered shortnose sturgeon.

5.1.3 Designated Critical Habitat – Chesapeake Bay DPS of Atlantic Sturgeon

On August 17, 2017, we published a final rule designating critical habitat for all five DPSs of Atlantic sturgeon (82 FR 39160; effective date September 18, 2017). The action area for this consultation overlaps with a portion of the James River unit of critical habitat designated for the Chesapeake Bay DPS. The critical habitat designation for the Chesapeake Bay DPS is for habitats that support successful Atlantic sturgeon reproduction and recruitment. In order to determine if the proposed action may affect critical habitat, we consider whether it would impact the habitat in a way that would affect its ability to support reproduction and recruitment. Specifically, we consider the effects of the project on the physical features of the proposed critical habitat. The essential features identified in the final rule are:

> (1) Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0 to 0.5 parts per thousand (ppt) range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
>
> (2) Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;

(3) Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and, (iii) Staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (e.g., at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.

(4) Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: (i) Spawning; (ii) Annual and interannual adult, subadult, larval, and juvenile survival; and, (iii) Larval, juvenile, and subadult growth, development, and recruitment (e.g., 13 °C to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) dissolved oxygen (DO) or greater for juvenile rearing habitat).

In this analysis, we consider the effects of the intake of cooling water and discharge of effluent (heat and pollutants) and vessel movements on the four PBFs. For each PBF, we identify the activities that have effects that overlap with the PBF and identify those activities that may affect the PBF. For each feature that may be affected by the action, we then determine whether any negative effects to the feature are insignificant or extremely unlikely to occur. In making this determination, we consider the action's potential to affect how each PBF supports Atlantic sturgeon's conservation needs in the action area.

Feature One: Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages

In considering effects to PBF 1, we consider whether the proposed action will have any effect on areas of hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages. Therefore, we consider how the action may affect hard bottom substrate and salinity and how any effects may change the value of this feature in the action area.

The James River in the area of CPS is downriver of the fall line, is tidal and freshwater year round, and is characterized as a meandering channel with adjacent oxbows. Vessels associated with CPS operations travel between the freshwater river upstream from the offloading facility or barge slip at CPS and the saline estuary downstream at the mouth of the James River. The waters within the action area exhibit varying salinity levels depending on drainage basin discharge. The entirety of the river within the action area is subject to tidal influence.

There is a relatively limited amount of hard-bottom substrate in low-salinity waters of the tidal James River. A survey of the river substrate from Richmond to Hopewell found that gravel, cobble, and bedrock accounted for only 16 percent of the surveyed river bottom. The majority of the river substrate in this part of the James River was mud and silt, accounting for approximately 67 percent of the surveyed substrate, while sand accounted for the remaining 17 percent (Austin 2012). Hard bottom habitat was predominantly located in the middle and lower portion of the study area from river buoy 166 to river buoy 121. Within this area, the largest area of continuous hard bottom habitat was found in the Jones Neck shipping channel cut. Other stretches of hard bottom habitat were found around the Turkey Island channel cut, and the areas of the river in proximity to buoy numbers 137, 150, 154, 156, and 160. Dominion's CPS is located along the James River CPS in proximity to buoy number 154.

Activities that overlap with the portion of the James River that contains PBF 1 include the portion of the vessel transit route that occurs water with salinity less than 0.05 ppt and the area of the river influenced by the intake of cooling water and discharge of effluent (heat and pollutants), where those areas also coincide with the presence of hard bottom substrate.

Intake and Discharge
Salinity in the area affected by the intake and discharge of water is less than 0.05%; however, there are only limited areas of hard bottom substrate near where outfalls 001 and 002 discharge into the mainstem river (Bilkovic *et al.* 2009, Austin 2012). The intake and discharge of water from CPS has no effect on salinity and no effect on hard bottom substrate. Therefore, these activities have no effect on PBF 1.

Transit
The upstream end of the vessel transit route between CPS to the mouth of the James River overlaps with the portion of the James River that contains PBF 1. However, project vessels will have no effect on this feature. This is because the project vessels will have no effect on salinity and will not interact with the bottom in this reach and therefore, there would be no impact to hard bottom habitat. The vessels will be loaded or unloaded at the CPS off-loading/loading facility by tying up at mooring points that extend riverward and are not expected to set an anchor. The vessels will operate in the channel where there is adequate water depth to prevent bottoming out or otherwise scouring the riverbed.

Conclusions for PBF 1
The continued intake and discharge of water for the operations of CPS and the transit of project vessels to and from CPS will not affect salinity or substrate type in the action area. Therefore, because the actions considered here will have no effect on hard bottom substrate and no effect on salinity it will have no effect on the value of hard bottom substrate in low salinity waters for settlement of fertilized eggs, refuge, growth, and development of early life stages. Based on these considerations, the continued operation of CPS and the issuance of the ITP will have no effect on PBF 1; that is, there will be no effect on how the PBF supports the conservation needs of Atlantic sturgeon in the action area.

Feature Two: Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development

In considering effects to PBF 2, we consider whether the proposed action will have any effect on areas of soft substrate within transitional salinity zones between the river mouth and spawning sites for juvenile foraging and physiological development; therefore, we consider effects of the action on soft substrate and salinity and any change in the value of this feature in the action area.

As noted above, salinity in the vicinity of the intake and discharge is below 0.5 ppt. As such, PBF 2 does not occur in the area affected by intake and discharge. The portion of the vessel transit routes downstream of the area where salinity is at or above 0.5 ppt contains PBF 2; soft substrates are abundant throughout this reach of the river.

Transit

PBF 2 occurs throughout the entire James River segment between the mouth of the James River and Richmond because the entire stretch of the river contains the appropriate salinity gradient and has at least some areas of soft substrate. Vessel movements in the James River channel overlap with the portions of the James River that contain PBF 2. Here we consider whether these activities may affect PBF 2 and if so, whether the effects are insignificant, discountable, or entirely beneficial. Transiting project vessels will have no effect on PBF 2. The operation of project vessels will not have any effect on salinity. The vessels will not interact with the river bottom and therefore, there would be no impact to soft substrate.

Conclusions for PBF 2

The only activity that overlaps with PBF 2 are vessel transits occurring in waters with salinity of 0.5 ppt or higher. The transit of these vessels will not affect salinity or substrate type in the action area. Therefore, because the actions considered here will have no effect on soft substrates and no effect on salinity it will have no effect on the value of this habitat for juvenile foraging and physiological development.

Feature Three: Water absent physical barriers to passage between the river mouth and spawning sites

In considering effects to PBF 3, we consider whether the proposed action will have any effect on water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: unimpeded movements of adults to and from spawning sites; seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and; staging, resting, or holding of subadults or spawning condition adults. We also consider whether the proposed action will affect water depth or water flow, as if water is too shallow it can be a barrier to sturgeon movements, and an alteration in water flow could similarly impact the movements of sturgeon in the river, particularly early life stages that are dependent on downstream drift. Therefore, we consider effects of the action on water depth and water flow and whether the action results in barriers to passage that impede the movements of Atlantic sturgeon.

Prevailing river depths at the CPS range from 2 to 39 feet at Mean Lower Low Water (MLLW) and the navigational channel is maintained (e.g., dredged) at 25 feet of water depth at MLLW to accommodate deep-draft vessels traveling upriver to the port at Richmond (VEPCO 2000). A bathymetric survey in front of CPS was conducted in 2018. Water depths immediately adjacent to the CWISs range from 29 to 33 feet, while water depths at outfalls range between 1 to 15 feet. Depths at the intakes and outfalls both rapidly descend to mid-channel depths ranging from 44.1 to 50.9 feet (Figure 7). The James River at the CPS experiences a mean tidal amplitude of approximately 2.0 feet. The water level in this portion of the James River fluctuates greatly with an extreme high elevation of 19.0 feet and an extreme low elevation of -3.5 feet. Maximum tidal current is approximately 2.8 fps with average maximum ebb and flood tidal currents of 1.34 fps and 1.5 fps, respectively (Revised Draft EA). We are not aware of any complete barriers to passage for Atlantic sturgeon in the action area; that is, we do not know of any structures or conditions that prevent sturgeon from moving up- or downstream within the river. The lowermost dam on the James River, Boshers Dam at approximately rkm 160, is a barrier to sturgeon passage; however, this structure is upriver of the action area for this consultation. In the absence of barriers to sturgeon passage, we conclude that PBF 3 occurs throughout the entire James River between the river mouth of and Richmond and therefore is present throughout the action area. Activities that overlap areas where PBF 3 occurs include the intake of cooling water, discharge of effluent, and the vessel transit route.

Intake and Discharge
The power-generating units at CPS utilize a once-through cooling water system that withdraws water from the James River through CWISs. PBF 3 occurs in the portion of the action area influenced by cooling water withdrawals. CPS has a design intake flow of approximately 1,090 million gallons per day (MGD). The James River in the vicinity of CPS CWISs is approximately 500 feet wide and flows in a generally southeasterly direction. Water depths directly in front of the intakes generally range from 29 to 33 feet with a typical depth of 31 feet. The intake pipes associated with the CWISs are constantly submerged and aligned flush with and parallel to the south shoreline and intake structures are designed to operate at river levels ranging from 3.5 feet below mean sea level (MSL) to 19.0 feet above MSL (Dominion 2019). Because all water that is withdrawn from the river is discharged back to the river, water withdrawals at CPS have no effect on the depth of water in the action area.

Dominion has provided information on the area of influence (AOI) from the CWIS. As described in the Conservation Plan, the AOI was calculated as a conservative zone of hydraulic influence (i.e., it errs on the side of overestimating the size of the AOI) on the movement of motile, non-motile and limited mobility life stages of fish and shellfish. The AOIs do not represent an area of potential direct impact, but instead a conservative estimate of the potential area of hydraulic influence of the CPS CWIS. Fish and shellfish can occur in the AOI and avoid, or not be drawn into the facility. The AOI is calculated based on conservative assumptions including no ambient velocity and low water depth; thus, it represents the maximum areal extent associated with the evaluated threshold velocities of 0.5 feet per second (fps), 0.3 fps and 0.1 fps. Maximum tidal current is approximately 2.8 fps with average maximum ebb and flood tidal currents of 1.34 fps and 1.5 fps, respectively (Revised Draft EA); thus, the AOI calculated with no ambient velocity is expected to result in an overestimate of the size of the AOI. Ambient velocities are typically expected to predominate and therefore influence movement of non-motile and limited mobility life stages such as Atlantic sturgeon larvae. As such, we expect the dispersal of Atlantic sturgeon past CPS to be driven by ambient river flows. The available information on the AOI of the CPS intakes does not support a conclusion that the intake of water for the CWIS would result in a barrier to dispersal of larvae downstream or create a barrier for adults moving up or downstream past CPS. The AOI is estimated as follows (Dominion 2016d):

- The AOI based on a threshold velocity of 0.5 fps is conservatively calculated as a semi-circle with a radius of 69 feet centered at the CWIS. The threshold velocity of 0.5 fps is associated with motile fishes, where it is generally assumed that fish subject to 0.5 fps and lower velocities are able to swim freely and avoid impingement. For example, the §316(b) rule assumes impingement is minimized at intakes with 0.5 fps through-screen velocities.

- The AOI based on a range in velocity thresholds from 0.1 fps to 0.3 fps, representing these ambient velocities (e.g., at slack tide or under gentle breeze conditions in a lacustrine system) is calculated as a rectangular area ranging from:

    - 2,772 feet along the river axis (i.e., 1,386 feet upstream and 1,386 feet downstream from the CWIS) and 359 feet wide across the river (for comparison, the James River is approximately 500 feet wide at this location), centered at the CWIS using a velocity threshold of 0.3 fps;

    - 8,315 feet along the river axis (i.e. 4,158 feet upstream and 4,158 feet downstream from the CWIS) and extending across the river (which is approximately 500 feet wide at this location), centered at the CWIS using a velocity threshold of 0.1 fps.

The effluent discharges from Outfalls 001 and 002 in the mainstem of the James River and from Outfall 003 in Farrar Gut can result in elevated water temperatures in areas that overlap with PBF 3. Larvae are expected to move downstream past CPS in September and October. There is no information on the thermal plume to suggest that there are times in October when bottom temperatures would exceed the maximum thermal tolerance for larvae (24.5°C, ASMFC 2012) as they move pass CPS at or near the bottom, thus the thermal plume is not expected to impact the habitat in a way that would affect their downstream migration during October. Water temperatures in the mixing zone of the James River are influenced by ambient river temperatures (which are expected to decrease over the September – October period as the weather cools) and the discharge of heated effluent. The available monitoring information indicates that water temperatures near the bottom are at least occasionally warmed above ambient due to the discharge.

Data from August suggest that bottom water temperatures in some portions of the mixing zone would at least occasionally be above the thermal tolerance for sturgeon larvae (24.5°C, ASMFC 2012) while information for October indicate that temperatures are not likely to be elevated above this level. There is no information on bottom water temperatures for September; however, as ambient river temperatures cool between August and October it is reasonable to expect that conditions will be between those recorded for August and October. As such, it is possible that in the early parts of September there may be areas of the mixing zone with temperatures above the thermal tolerance of Atlantic sturgeon larvae; however, the bottom oriented nature of these larvae, their preference for the deepest part of the channel, their swim up and drift behavior that allows them to select preferred habitats, and the very short period of time that larvae would spend moving through the mixing zone makes exposure to these elevated temperatures extremely unlikely. It is important to note that by October, even with CPS operating at maximum capacity, average bottom temperatures remained within the tolerance range for this life stage (i.e., less than 24.5°C). Thus, while it is possible that there may be portions of the mixing zone, particularly closest to the outfall, where water temperatures are elevated above the thermal tolerances for larvae during the earliest part of the seasonal period when Atlantic sturgeon larvae may move past CPS, during the majority of the period when movement is likely to occur, temperatures are within the thermal tolerance of this life stage. Based on this analysis, the thermal plume does not create a barrier to the downstream movement of larvae.

Telemetry data in the James River indicate that the fall spawning population migrate upstream as water temperatures approach 26°C (Dominion 2019). Laboratory studies suggest that prolonged exposure of juvenile Atlantic sturgeon to temperatures above 28ºC may result in sublethal effects and that such temperatures may be avoided when alternative (cooler) habitats are available (Niklitschek 2001, Niklitschek and Secor 2005, Niklitschek and Secor 2010). However, in southern rivers suitable temperatures for juvenile Atlantic sturgeon habitat range as high as 30C (ASMFC 2017). Little information on thermal tolerances of adult Atlantic sturgeon is available; however, adults have been documented in waters as high as 33.1ºC in South Carolina (ASMFC). In the James River, Balazik et al. (2012) reports captures of adult Atlantic sturgeon in water temperatures as high as 30ºC.

No information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. As discussed more fully in the sections that follow and for purposes of considering effects of thermal tolerances, shortnose sturgeon are a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities (see *Thermal Tolerances - Atlantic Sturgeon* section). Lab studies indicate that thermal maxima for juvenile shortnose sturgeon are 33.7 (±0.3) – 36.1°C(±0.1) (92.7-97°F), depending on endpoint (loss of equilibrium or death) and acclimation temperature (19.5 or 24.1°C) (Ziegeweid *et al*. 2008a and 2008b).

In this analysis, we consider data from thermal modeling that include Unit 4 because these data represent a conservative estimate (a scenario that errs on the side of overestimating potential impacts)of the reach of the thermal plume. Modeling done under full operating load conditions prior to the retirement of Unit 4 suggest that discharges could raise surface river temperatures above 33.7°C in August if the facility is operating in the range of 94% of capacity during a low water slack tide (VEPCO 2000). Adult Atlantic sturgeon may begin moving upstream past CPS in August. As described in the *Description of the Proposed Action* section of this Opinion, following the retirement of Units 3 and 4, the mode of operation for CPS transitioned from base load operation to operating Units 5 and 6 at varying load levels while Units 7 and 8 remain base loaded. We expect that it is unlikely that CPS will operate at or near 94% of capacity within the proposed five-year duration of the permit. Based on intake operations at the four remaining generating units at CPS, Dominion projects that future operations at the facility would continue to operate at approximately 60% of the DIF. As such, the discussion that follows likely overestimates the impact of the thermal plume under the operational conditions that are expected over the five-year life of the permit.

To be outside of lethal temperatures at or above 33.7°C during low water (as modeled in the studies including Unit 4), fish need to be downstream of the facility in the vicinity of the Jones Neck oxbow. This suggests that in certain circumstances (low water conditions, high ambient water temperatures, facility operating near capacity), the thermal plume may preclude Atlantic sturgeon from moving upstream past the project. In these circumstances, we would expect adults to hold downstream and then move upstream when conditions improve (likely at the turn of the tide). Because we do not expect these poor conditions to persist for more than a tidal cycle (i.e., six hours), we do not expect any consequences to adults that may need to temporarily hold below the Jones Neck oxbow. It is also important to note that these conditions are not expected to occur throughout the entirety of the migration period and are expected only in extreme circumstances and would be even less common now given the reduced operations of the plant. t Across the available studies used in our analysis, temperature data for both surface and bottom water indicate that overall river temperatures vary from season to season, and from year to year. For example, while the available data shows that ambient bottom temperatures during August 1997 and 1998 were warmer than 28°C (VEPCO 2000), later work conducted from August – October of 2011 shows that spawning condition adults were collected in the vicinity of CPS in water temperatures within the range of 20-25°C (Balazick et al. 2012b). In addition to these findings, gill netting and telemetry studies conducted from 2012-2014 indicate that spawning condition adults move pass CPS up to the fall line at rkm 155, with some adults returning to these upriver spawning locations in subsequent years (Balazick and Musick 2015). This information suggests that the discharge of thermal effluent is extremely unlikely to preclude any Atlantic sturgeon from completing upriver migrations.

Based on the available information, it is extremely unlikely for ambient surface and bottom temperatures to reach or exceed 28°C in October. While surface water temperature increases due to the influence of the thermal plume were shown to cause temperatures of approximately 29.1°C during low slack surveys in October 1997 (VEPCO 2000), thermal data for the bottom and the vertical profile at the surface (i.e. power station side, middle, opposite side of the river) indicate that there is space for any Atlantic sturgeon to travel under or around areas where the temperature exceeds 28°C during the latter portion of the spawning season. This information suggests that the discharge of thermal effluent is extremely unlikely to preclude any Atlantic sturgeon from completing downriver migrations. As such, we would not expect the thermal plume to act as a barrier to upstream or downstream passage of pre or post-spawn adults.

Based on the thermal studies described above, the magnitude of impacts associated with elevated water temperatures will be influenced by seasonal variations in air and water temperature and tidal cycling (VEPCO 2000). We expect life stage to influence how elevated water temperatures affect sturgeon movement in areas where PBF 3 occurs. Eggs and larvae that are dependent on downstream drift have a reported thermal tolerance of 15 – 24.5°C. Age-0 juveniles begin migrating downstream when water temperatures reach 20°C and peaks between 12 and 18°C (documented range of 0.5 to 27°C) (ASMFC 2012). We do not expect the spring spawning population to encounter elevated temperatures associated with heated discharges because water temperatures will have recovered towards ambient temperatures with distance from the facility. The spring cohort typically occupies the river from river mile 18 to river mile 67 (15 - 64 miles downstream of CPS). Behavioral studies indicate that Atlantic sturgeon are sensitive to ambient temperature conditions (Musick 2005). We do not anticipate that sturgeon would be exposed to rapid changes in water temperature, and the life stages found in areas that are impacted by heated discharges near CPS (i.e. age-0 juveniles and adult sturgeon) are expected to demonstrate avoidance behavior and attempt to escape heated water. Therefore, any effects to the value of PBF 3 to the conservation of the species in the action area will be so small that they cannot be meaningfully measured, detected or evaluated and effects to PBF 3 are insignificant.

Transit
As stated above, PBF 3 occurs throughout the mainstem of the James River between the mouth of the river and Richmond because there are no barriers to sturgeon passage. Vessel movements and docking/undocking maneuvers associated with CPS operations overlap with the portions of the James River that contain PBF 3. Here we consider whether these activities may affect PBF 3 and if so, whether the effects are insignificant, discountable, or entirely beneficial.
Transiting project vessels and vessels performing docking/undocking maneuvers at the CPS barge slip will have no effect on PBF 3. Vessel operations do not result in habitat alterations that impede the movement of Atlantic sturgeon; therefore, vessel operations will have no effect on PBF3.

Conclusions for PBF 3
Any effects to water depth and water flow will be insignificant. The proposed action will result in temporary temperature increases in the action area. However, based on the assessment here, any effects of increases in water temperature due to the discharge of heated effluent will be so small that they cannot be meaningfully measured, evaluated, or detected. Therefore, any effects to the value of PBF 3 to the conservation of the species in the action area will be so small that they cannot be meaningfully measured, detected, or evaluated and effects to PBF 3 are insignificant.

Feature Four: Water with the temperature, salinity, and oxygen values that, combined, provide for dissolved oxygen values that support successful reproduction and recruitment and are within the temperature range that supports the habitat function
In considering effects to PBF 4, we consider whether the proposed action will have any effect on water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment. Therefore, we consider effects of the action on temperature, salinity and dissolved oxygen needs for Atlantic sturgeon spawning and recruitment. These water quality conditions are interactive and both temperature and salinity influence the dissolved oxygen saturation for a particular area. We also consider whether the action will have effects to access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

The waters within the action area exhibit varying salinity levels depending on drainage basin discharge and the entirety of the James River within the action area is subject to tidal influence. The tidal freshwater of the James River extends from the fall line in Richmond to the mouth of the Chickahominy River (Musick, 2005). The entirety of the action area contains PBF 4.

Activities that overlap with the portion of the James River that contains PBF 4 include the intake of cooling water, discharge of effluent, and the vessel transit route.

Intake and Discharge

Here we consider how water withdrawals and effluent discharges may affect PBF 4. Cooling water withdrawals will not have any effect on temperature, salinity, or dissolved oxygen. Effluent discharges (heated and polluted) will not have any effect on salinity; below we consider effects to dissolved oxygen and water temperature.

As discussed above, discharges from Outfalls 001 and 002 in the mainstem of the James River and from Outfall 003 in Farrar Gut result in elevated water temperatures. Thermal studies indicate that throughout the year, the ambient water temperature at Outfalls 001 and 002 is below 29.3°C 90% of the time (VDEQ 2016). As water moves past outfalls in the mainstem of the James River on both incoming and outgoing tides, surface water temperature increases between 1.7°C and 2°C just after passing the discharge points at Outfalls 001 and 002 and prior to reaching Farrar Gut (VEPCO 2000). At Farrar Gut, the tidal cycle influences the thermal plume, confining it to the oxbow on the incoming tide and extending it downriver on the outgoing tide. Study results indicated that water temperatures recover toward ambient conditions with distance from Farrar Gut's confluence with the James River. Comparison of temperature change data for the sampling station located in the James River mainstem nearest to the Jones Neck cut-off (i.e. 3 miles downstream of CPS) demonstrated that the overall temperature change at this station is identical on either tide (VEPCO 2000). These data suggest that the thermal plume does not extend downstream past Jones Neck.

Atlantic sturgeon are expected to demonstrate avoidance behavior and attempt to escape heated water and regions of hypoxia (dissolved oxygen< 4 mg/L). Based on the thermal studies described above, the magnitude of impacts associated with elevated water temperatures will be influenced by seasonal variations in air and water temperature and tidal cycling (VEPCO 2000). We do not expect the spring spawning population to encounter elevated temperatures associated with heated discharges because water temperatures extending across the entire width of the river will have recovered towards ambient temperatures with distance from the facility. At Turkey Island oxbow (i.e. 7 miles downstream of CPS), recorded water temperatures were an average of 1°C above ambient conditions (VEPCO 2000). The spring cohort typically occupies the river from river mile 18 to river mile 67 (15 - 64 miles downstream of CPS), while adults from the fall spawn cohort have been detected from river mile 87 up to the fall line at river mile 96 (5-14 miles upstream of CPS). Based on these considerations, we conclude that any effects to the value of PBF 4 to the conservation of the species that are related to heated discharges in the action area will be so small that they cannot be meaningfully measured, detected or evaluated and effects to PBF 4 are insignificant.

Pollutants found in the discharges from Outfalls 001 and 002 in the mainstem of the James River and from Outfalls 003, 004, 005 in Farrar Gut include nutrients, microorganisms, and dissolved gas (see Table 5). The presence of these pollutants can be contribute to hypoxic conditions (Muscik 2005). The mainstem of the James River is listed on the EPA’s 303(d) list of impaired waters for dissolved oxygen (VDEQ 2020). However, dissolved oxygen in the tidal freshwater James River typically varies between 13 mg/L during winter months to 6 mg/L during the summer, with no values of less than 5 mg/L recorded (Moore et al. 2006). Dissolved oxygen concentrations measured near CPS as part of the CWA 316(a) demonstration study, indicated that sufficient oxygen levels exist for fish even in the hottest parts of the summer (VEPCO 2000). Based on the water quality assessments described above, we conclude that PBF 4 occurs in the tidally influenced freshwater portion of the action area. As noted in the Fact Sheet for Dominion's VPDES permit, CPS was addressed in the Chesapeake Bay TMDL. The TMDL allocates loads for total nitrogen, total phosphorus, and total suspended solids to protect the dissolved oxygen and SAV criteria in the Chesapeake Bay and its tidal tributaries. Dominion's VPDES permit will maintain the Water Quality Standards of 9VAC25-260 et seq. Discharge limits are in compliance with the CWA for Section 303(d) with respect to TMDL for the receiving water body. Because these water standards were established, in large part, to protect aquatic life use, which includes adult sturgeon and larvae, and because discharges are within required limits, we conclude that these VDEQ water quality requirements have a beneficial impact on water quality in the action area. We therefore conclude that any effects to the value of PBF 4 to the conservation of the species that are related to polluted discharges in the action area will be so small that they cannot be meaningfully measured, detected or evaluated and effects to PBF 4 are insignificant.

Transit

As stated above, PBF 4 occurs in the tidally influenced freshwater portion of the action area. Vessel movements and docking/undocking maneuvers associated with CPS operations overlap with the portions of the James River that contain PBF 4.

Transiting project vessels and vessels performing docking/undocking maneuvers at the CPS barge slip will have no effect on PBF 4. Vessel operations do not result in habitat alterations that effect salinity, temperature, or dissolved oxygen; therefore, vessel operations will have no effect on PBF 4.

The proposed action will result in temporary temperature increases and polluted discharges in the action area. However, based on the assessment here, any effects to water quality due to effluent discharges are expected to be so small that they cannot be meaningfully measured, evaluated, or detected. Therefore, any effects to the value of PBF 4 to the conservation of the species in the action area will be so small that they cannot be meaningfully measured, detected or evaluated and effects to PBF 4 are insignificant.

Summary of effects to critical habitat

We have determined that effects to PBF 1, PBF 2, PBF 3 and PBF 4 are not able to be meaningfully measured, detected or evaluated and are therefore insignificant. Based on this, the action is not likely to adversely affect critical habitat designated for the James River DPS of Atlantic sturgeon.

6.0 STATUS OF THE CHESAPEAKE BAY DPS OF ATLANTIC STURGEON

We have considered the best available information to determine from which DPS individuals in the vicinity of CPS are likely to have originated. The CWIS operations associated with the proposed action take place in the tidal, freshwater reach of the James River where CPS is located including intake pipes that bring water into CPS and trash racks that prevent debris from entering CPS. The James River historically supported the largest stock of Atlantic sturgeon in the Chesapeake Bay. The majority of the adults in the river are likely to originate from the James River and thus, the Chesapeake Bay DPS (Hildebrand and Schroeder 1928, ASSRT 2007, Hager *et al.* 2011, NMFS 2012).

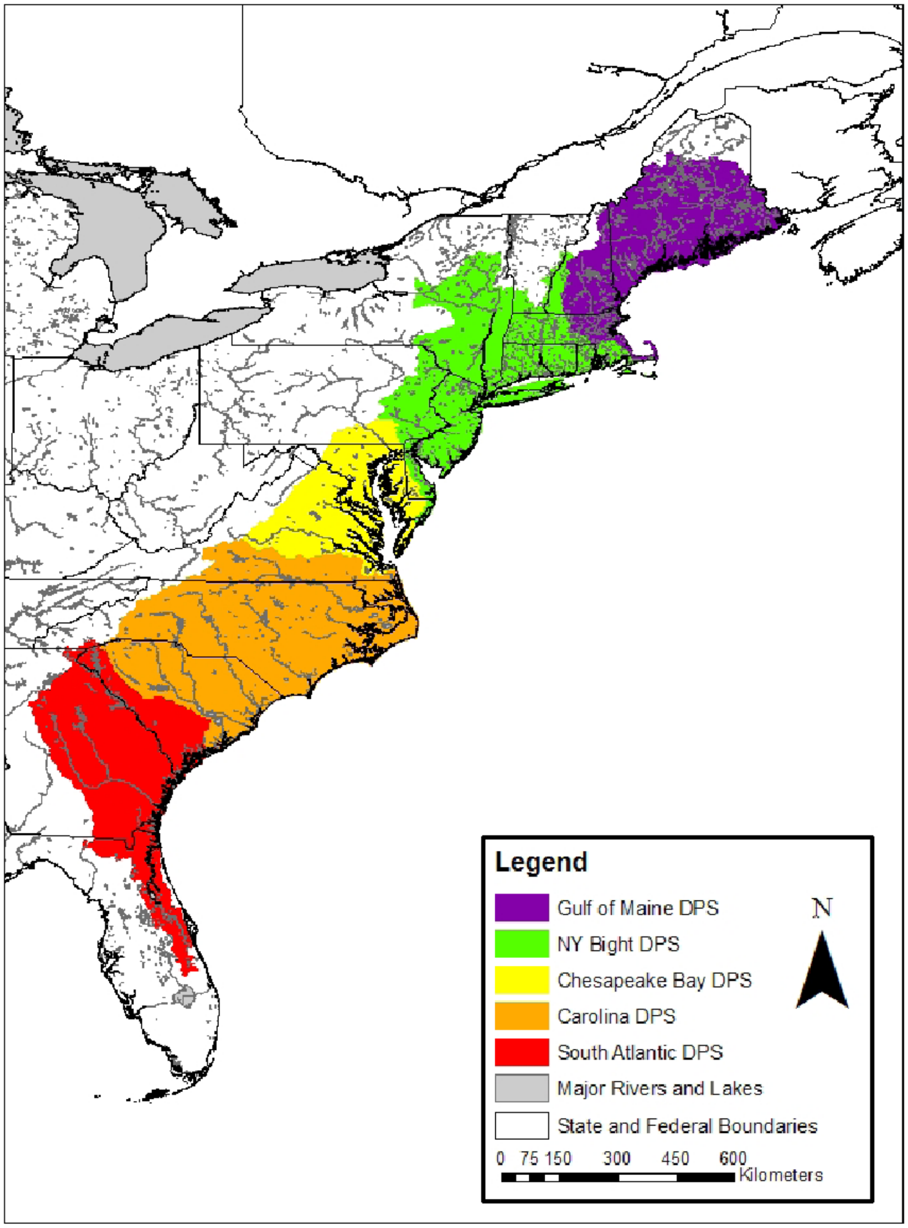
Atlantic sturgeon continue to use the James River for spawning. In October 2018, researchers from the Rice Rivers Center of VCU collected over 300 Age-0 sturgeon downriver of CPS (*Sturgeon Making a Comeback in the James River*, Chesapeake Bay Magazine, October 30, 2018). Tracking and observed activity of adult sturgeon suggests spawning occurs in the late summer to early fall upriver of CPS (Balazik *et al.* 2012a, Greenlee *et al.* 2017). Therefore, this collection of Age-0 sturgeon suggests that Atlantic sturgeon spawned upriver of CPS in the fall move downriver, past the facility, after hatching. Because early life stages (eggs and larvae), yearlings, and juveniles do not leave their natal river or estuary, any Atlantic sturgeon from these life stages in the James River would have originated from the Chesapeake Bay DPS. We do not expect subadults of any DPS to be in the vicinity of the CPS CWISs because the facility is located in a portion of the James River where water is fresh year round and subadults are not known to occur in this type of habitat (Hager *et al.* 2011).

As noted above, we only anticipate adverse effects to Atlantic sturgeon originating from the Chesapeake Bay DPS. The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon and then provides information specific to the status of the Chesapeake Bay DPS.

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott 1988; ASSRT 2007; T. Savoy, CT DEP, pers. comm.). NMFS has delineated U.S. populations of Atlantic sturgeon into five DPSs (77 FR 5880 and 77 FR 5914, February 6 2012). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 7). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine, and riverine environment that occur far from natal spawning rivers.

The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are listed as endangered, and the Gulf of Maine DPS is listed as threatened (77 FR 5880 and 77 FR 5914, February 6 2012). The effective date of the listings was April 6 2012. The DPSs do not include Atlantic sturgeon spawned in Canadian rivers. Therefore, Canadian spawned fish are not included in the listings.

Figure 8. Map Depicting the five Atlantic sturgeon DPSs



6.1 Atlantic sturgeon Life History

Atlantic sturgeon are an anadromous, benthic foraging fish that are relatively slow-growing, late to mature, and long-lived (e.g., up to 64 years although the typical lifespan is probably much shorter). Spawning takes place in well-oxygenated areas of tidal-affected rivers that have flowing freshwater[3] at the time of spawning and hard bottom substrate such as cobble, gravel, and bedrock. Within minutes of being fertilized, the eggs become sticky and adhere to the substrate for the relatively short and temperature-dependent period of larval development. Upon hatching, Atlantic sturgeon are nourished by a yolk sac for 8 to 10 days, and then transition to benthic foraging. This larval stage ends at about 41 days post hatching at which time the Atlantic sturgeon are referred to as juveniles[4] (Bath *et al*. 1981). Juvenile growth and development continues for months to years in brackish waters of the natal estuary until the sturgeon make their first emigration to marine waters. This marks the beginning of the next life stage, referred to here as the subadult stage, but by other authors as late-stage juveniles or marine migrants. In the marine environment, subadults mix with adults and subadults from other river systems, travel long distances in marine waters, aggregate in both ocean and estuarine areas at certain times of the year, and exhibit seasonal coastal movements in the spring and fall. Tagging records and the relatively low rate of gene flow reported in population genetic studies provide evidence that Atlantic sturgeon return to freshwater of their natal river to spawn every 1-5 years (males) or 2-5 years (females) (NMFS and USFWS 2007, NMFS 2017).

The life history of Atlantic sturgeon can be divided up into five general categories as described in Table 7 below (adapted from ASSRT 2007).

[3] Freshwater is water containing less than 1,000 milligrams per liter of dissolved solids, most often salt (http://water.usgs.gov/edu/watercyclefreshstorage.html).

[4] Some of the published literature for Atlantic sturgeon uses the term juvenile to refer to all sexually immature Atlantic sturgeon, including sexually immature fish that have emigrated from the natal river estuary. We use "juvenile" in reference to immature fish that have not emigrated from the natal river estuary, and we use the term "subadult" for immature Atlantic sturgeon that have emigrated from the natal river estuary.

Age Class	Size	Description
Egg		Fertilized or unfertilized
Larvae		Negative photo-taxic, nourished by yolk sac
Young of Year (YOY)	**0.3 grams <41 cm TL**	Fish that are > 3 months and < one year; capable of capturing and consuming live food
Non-migrant subadults or juveniles	**>41 cm and <76 cm TL**	Fish that are at least age 1 and are not sexually mature and do not make coastal migrations.
Subadults	**>76cm and <150cm TL**	Fish that are not sexually mature but make coastal migrations
Adults	**>150 cm TL**	Sexually mature fish

Table 7. Descriptions of Atlantic sturgeon life history stages

The whereabouts of subadult and adult Atlantic sturgeon once they leave coastal estuaries in the fall is uncertain. Studies have found that at least some of the fish that migrate from an estuary in the fall remain relatively nearby in deeper marine waters throughout the winter (Oliver *et al*. 2013, Taylor *et al*. 2016) whereas the results of another study showed that adult Atlantic sturgeon can also move about across a large part of their marine range during the winter, and do not move from the river estuary in the fall to a specific overwintering area where the fish reside throughout the winter (Erickson *et al*. 2011). Aggregation areas off of the south shore of Long Island, New York, and off of the Virginia/North Carolina coastline include sturgeon from multiple DPSs (Laney *et a*l. 2007, Dunton *et al*. 2010, O'Leary *et al*. 2014, Dunton *et al*. 2015) which further suggests wintering areas are not specific to a particular DPS and are not necessarily close to estuaries that the fish return to for spawning or foraging in the spring.

6.2 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay DPS includes the following: all Atlantic sturgeon that originate from rivers that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, Virginia. Based on genetics analysis of tissue samples collected from Atlantic sturgeon captured in marine waters, the Chesapeake Bay DPS is more prevalent in the middle of the marine range (e.g., the Connecticut River, Long Island Sound, off of Rockaway, New York, and the Delaware coast) than in marine areas sampled further to the north and south (Laney *et al*. 2007, Wirgin *et al*. 2012, Waldman *et al*. 2013, O'Leary *et al.* 2014, Wirgin *et al.* 2015).

Within its range, Chesapeake Bay DPS Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT, 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT, 2007). Today, there are four known spawning subpopulations for the Chesapeake Bay DPS, one each for the Pamunkey River and Marshyhope Creek, and two for the James River.

The existence of the Pamunkey River spawning subpopulation was identified in 2013 after the capture of spawning condition adults (e.g., males expressing milt, and females with eggs) within tidal freshwater of the river during the late summer to early fall (i.e., August - October) (Hager *et al.* 2014). Based on the capture of 17 sturgeon, Kahn *et al.* (2014) estimated 75 adults (95% confidence interval = 17–168 adults) spawned in the river in 2013. There are no other estimates of abundance for this spawning subpopulation or trends in abundance.

The Marshyhope Creek spawning subpopulation was identified in 2014, likewise after the capture of spawning condition adults during the late summer to early fall. Twenty-six adults, including males expressing milt and females with ripe eggs, have been captured in Marshyhope Creek since 2014. DNA analysis is ongoing to determine whether the sturgeon are part of a naturally occurring population or are hatchery fish that were released into the Nanticoke River in 1996 (Secor *et al*. 2000, Richardson and Secor 2016, Richardson and Secor 2017). There are no estimates of abundance or trends in abundance for this spawning subpopulation.

At the time of listing, the James River was the only known spawning river for the Chesapeake Bay DPS and spawning was believed to occur only in the spring, from approximately April – May, based on historical and current evidence (NMFS and USFWS 2007). Subsequently, new information for when and where spawning-condition adults were captured and tracked in the river led to the conclusion that Atlantic sturgeon spawn in the James River in both the spring and in the late summer to early fall (Balazik *et al*. 2012b, Balazik and Musick 2015).

Age to maturity for Chesapeake Bay DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is 5 to 19 years for Atlantic sturgeon originating from South Carolina rivers (Smith *et al.*, 1982) and 11 to 21 years for Atlantic sturgeon originating from the Hudson River (Young *et al*., 1988). Therefore, age at maturity for Atlantic sturgeon of the Chesapeake Bay DPS likely falls within these values.

The distribution of Chesapeake Bay DPS Atlantic sturgeon and their reliance upon both estuarine and marine waters exposes each life stage to multiple threats including degraded water quality in estuarine waters, bycatch in state and federally-managed fisheries, and vessel strikes. Some of the impact from the threats that facilitated the decline of the Chesapeake Bay DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). Overall, the 2017 ASMFC stock assessment determined that abundance of the Chesapeake Bay DPS is "depleted" relative to historical levels (ASMFC 2017). The assessment also determined there is a relatively low probability (37%) that abundance of the Chesapeake Bay DPS has increased since the implementation of the 1998 fishing moratorium, and a 30% probability that mortality for the Chesapeake Bay DPS exceeds the mortality threshold used for the assessment (ASMFC 2017).

We do not currently have enough information about any life stage to establish a trend for the Chesapeake Bay DPS of Atlantic sturgeon. The Chesapeake Bay DPS is currently at risk of extinction given (1)precipitous declines in population sizes and the protracted period in which sturgeon population have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect the potential for population recovery.

Adult Atlantic sturgeon enter the James River in the spring, with at least some eventually moving as far upstream as Richmond (river mile 96; rkm 155), which is also the head of tide and close to the upstream extent of Atlantic sturgeon in the river given the presence of Boshers Dam at the fall line (approximately rkm 160). Genetics results from Balazik *et al*. (2017) corroborate telemetry results showing that two separate spawning groups utilize the James River. Atlantic sturgeon occupy the river from river mile 18 to river mile 67 in the spring (April-May) before some depart from the river in June when water temperatures are around 24° C (Hager *et al.*, 2011). As water temperatures approach 26°C in the late summer through early fall (August-Oct), collection and tracking data indicate that mature Atlantic sturgeon aggregate in the freshwater portion of the James River upstream of river mile 67 (rkm 108). Sturgeon in this second spawning group enter the James River during August and out migrate by the end of November (Balazik *et al*. 2012a, Balazik and Musick 2015). Adults are undetected on tracking arrays in the lower river by December suggesting that adult sturgeon leave the James River for the winter (Bushnoe *et al.* 2005, Hager 2011, Balazik *et al*. 2012a).

The exact spawning ground for the James River is unknown but the fall and spring spawning areas are different, likely as a result of the movement of the salt wedge (Balazik and Musick 2015). Based on modeling work using features associated with spawning habitat (e.g. suitable substrate), Bushnoe *et al.* (2005) concluded that the Turkey Island oxbow and the Jones Neck oxbow were potential spawning sites for Atlantic sturgeon in the James. Balazik and Musick (2015) report that during the spring spawning period, adult Atlantic sturgeon were observed breaching around Sturgeon Point (rkm 90). Ryder (1890) describes Atlantic sturgeon breaching coinciding with spring spawning runs. For spring spawning, adults have been detected as far upstream as Curles Neck Swamp (Balazik and Musick 2015) and for fall spawning, adults have been detected up to the fall line at rkm 155 (Balazik *et al*. 2012a). During the 2016 fall spawning season, acoustic telemetry data showed multiple adult female Atlantic sturgeon between rkm 140 to 150 (Greenlee *et al*. 2017).

Early life stages (i.e. eggs and larvae) would be expected to be present in spawning habitats, as habitat specific to these age classes tends to be restricted to spawning areas. Because information on YOY, juvenile, and subadult Atlantic sturgeon in the James River is limited, not much can be determined about distribution and movements for these age classes. According to Balazik *et al*. (2012a), Atlantic sturgeon YOY inhabit the James River year round and congregate in the main channel. Tracking data has provided evidence that migratory juveniles inhabit the lower part of the river. The results of tracking and gill net efforts in Burwell Bay (rkm 40) suggests that this location is a nursery area for migratory juveniles (Balazik *et al*. 2012a).

Subadult Atlantic sturgeon inhabit the fresh water portions of their natal river for at least the first year of their life before migrating out to sea (Secor *et al.* 2000). Hager *et al*. (2011) observed that in the James River, subadults occupy a diverse depth range while searching for suitable habitat. The peak subadult population for the spring occurs in late May through early June when water temperatures reach 26°C in the James River. Tracking data provides evidence that larger subadults immigrate into the James River in the fall from the Delaware and subsequently spend the coldest months of the year upriver around rkm 77 (river mile 48). This region is completely fresh and contains very deep habitats with complex benthic composition and topography. This subadult winter holding area is located far above those selected by smaller juveniles that appear to occupy slightly brackish waters near rkm 40 (river mile 25) during the same period (Hager *et al.* 2011).

7.0 ENVIRONMENTAL BASELINE

Environmental baseline refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions; the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation; and, the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR § 402.02). The environmental baseline therefore, includes the effects of several activities that may affect the survival and recovery of Atlantic sturgeon in the action area and the quantity or quality of their habitat. The activities that shape the environmental baseline in the action area of this consultation generally include: dredging operations, actions that impact water quality, scientific research, shipping and other vessel traffic, fisheries, and recovery activities associated with reducing those impacts.

7.1 Factors Affecting Atlantic sturgeon in the Action Area

Fisheries

Atlantic sturgeon have been observed captured in hook-and-line gear of recreational fisheries, yet the number of interactions that occur annually is unknown and while most Atlantic sturgeon are likely to be released alive, we currently have no information on post-release survival. Recreational fisheries within the tidal reach of the James River include largemouth bass, blue catfish, Channel catfish, flat head catfish, striped bass, American Shad, Hickory shad, and black crappie (VDGIF webpage for James River-Tidal, downloaded August 2020). Despite their popularity as a sport fish, blue and flathead catfish are considered invasive species in the

Chesapeake Bay; blue catfish have rapidly expanded into nearly every major tributary in the Chesapeake Bay watershed, and flatheads are becoming more of an issue in lower-salinity tributaries. Both blue and flathead catfish are likely negatively affecting native species and the Chesapeake Bay ecosystem (NOAA, CBO webpage for Invasive Catfish, downloaded March 2018). There is speculation but no evidence that blue catfish are negatively impacting Atlantic sturgeon reproduction in the James River by preying on early life stages or outcompeting them for habitat (Bay Journal 2016).

Bycatch of Atlantic sturgeon in commercial fisheries using anchored gillnet and trawl gear is well documented (Stein *et al*. 2004, ASMFC 2007, Dunton *et al*. 2010, NMFS NEFSC 2011). Incidental takes of Atlantic sturgeon in Virginia's anchored gillnet fishery targeting striped bass have also occurred. Tests of gear modifications have been inconclusive for whether they would reduce incidental take of Atlantic sturgeon in Virginia's striped bass fishery (Murray 2016). Subadult Atlantic sturgeon have also been incidentally captured in Virginia's staked gill net gear used to monitor the spawning stock of American shad. Murray (2016) reported that for the 18 years of data for the James River sampling, between 1 and 30 subadult Atlantic sturgeon were caught in the staked gill net, translating into a catch rate of 0.002 to 0.076 sturgeon/hour fished (using a standardized 273 m, 12.4 cm stretched mesh gill net).

The U.S. FWS Region 5 provides funds to Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and the District of Columbia to conduct fisheries surveys in state waters (rivers, estuaries, and nearshore ocean waters) that inform state management programs. There are several broad categories of fisheries surveys including: hook and line; beach seine; bottom trawl; fishway trap; boat electrofishing; long line; fyke net; gill net; haul seine; push net; and, backpack electrofishing. ESA-listed species, including the Atlantic sturgeon DPSs, may be affected by operation of the surveys. The U.S. Fish and Wildlife Service requested section 7 consultation and we completed a Biological Opinion in 2013 (NMFS 2013b). The Opinion provides an incidental take statement (ITS) by state for each fishery survey anticipated to result in take of ESA-listed species. For the state of Virginia, we anticipated the incidental take of up to 23 Chesapeake Bay DPS Atlantic sturgeon (no more than three lethal) over a five-year period. The actual take since 2013 has been seven Atlantic sturgeon. All were captured and released alive. We do not know how many of these belonged to the Chesapeake Bay DPS. Genetic analyses will be completed in the future to determine the origin of each Atlantic sturgeon that was incidentally captured.

Military Operations

Military activities in the James River include: underwater diving and salvage operations, helicopter rope suspension techniques, small boat launch and recovery, high-speed boat tactics training, small boat defense drills, and visit, board, search and seizure drills, integrated swimmer defense, submarine maintenance and system upgrades, sonar testing, towing of in-water devices, unmanned vehicle testing, and mine countermeasure testing. Some of these test events could include the potential for bottom object placement. The described training activities are not likely to adversely affect salinity, but may affect open passage and substrate (e.g., placement of structures, activities resulting in increased siltation or erosion of substrate). The training activities also may affect the species. For example, sonar testing and various in-water testing can produce sounds that disrupt normal sturgeon behaviors such as foraging and staging. Operation of small and large vessels can injure or kill sturgeon (NMFS 2017).

Maintenance of Federal Navigation Channel

Dredging to maintain and deepen Federal navigation channels has been identified as a source of Atlantic sturgeon incidental take and mortality. The James River Federal navigation channel runs through the action area and is routinely maintained by the Army Corps of Engineers via dredging. To better inform how dredging may affect Atlantic sturgeon, five subadult sturgeon (TL ranged from 77.5 to 100.0 cm) were captured in the James River and acoustically tagged to detect their movements in the vicinity of a cutterhead dredge. Although movements differed among the five fish, there was no evidence that the presence of an active dredging operation was a barrier to sturgeon movement. All of the tagged fish were actively tracked throughout a section of the James River during the dredging, including passage both upstream and downstream movements in the vicinity of the dredge (Reine *et al*. 2014). While no dredging has occurred in the vicinity of CPS CWIS in at least seven years (Dominion 2020), ongoing dredging projects in the Chesapeake Bay that have been the subject of Section 7 consultation include the James River Federal Navigation Project. Maintenance dredging in the James River has the potential to directly affect Atlantic sturgeon individuals from the New York Bight, Gulf of Maine; Chesapeake Bay, Carolina, and South Atlantic DPSs, causing them to become entrained in the hydraulic cutterhead dredge. These interactions are likely to cause mortality. Incidental take as a result of maintenance dredging is expected to occur at a rate of one sturgeon per year, with a total exempted take of 50 sturgeon over the 50-year time frame. One Gulf of Maine DPS, one New York Bight DPS, 50 Chesapeake Bay DPS, one Carolina DPS, and one South Atlantic DPS Atlantic sturgeon will be subadults. Juveniles or subadults from the Chesapeake Bay DPS could be taken as well. No take of any adult Atlantic sturgeon is anticipated (NMFS 2012a). Indirect impacts to sturgeon from either mechanical or hydraulic dredging include destruction of benthic feeding areas, disruption of spawning migrations, deposition of resuspended fine sediments in spawning habitat, modifying substrate and impacting the community structure of benthic macrofauna, contaminant resuspension, noise/disturbance, and alterations to hydrodynamic regime (Chytalo 1996, Winger *et al*. 2000, Smith and Clugston 1997, Breece *et al*. 2013).

Vessel Interactions

Private and commercial vessels operating in the action area of this consultation also have the potential to interact with Chesapeake Bay DPS Atlantic sturgeon. The effects of fishing vessels, recreational vessels, or other types of commercial vessels on Atlantic sturgeon in the action area may involve disturbance or injury/mortality due to collisions. While we do not have vessel strike data that is specific to the action area, we have information for the James River. During 2007-2010, researchers documented 31 carcasses of adult Atlantic sturgeon in the tidal freshwater portion of the James River, Virginia. Twenty-six of the carcasses had gashes from vessel propellers, and the remaining five carcasses were too decomposed to allow determination of the cause of death. The types of vessels responsible for these mortalities are unknown. Most (84%) of the carcasses were found in a relatively narrow reach that was modified to increase shipping efficiency (Balazik *et al*. 2012c). From 2011 to 2017, another 13 Atlantic sturgeon carcasses with evidence of a vessel strike were found in the Chesapeake Bay and 1 carcass was found on an Atlantic Ocean beach. Since we do not know where the sturgeon were struck and killed, we do not attribute these carcasses to the James River. All numbers are a minimum count of the Atlantic sturgeon that are struck and killed in the James River since it is unlikely that all of the carcasses are found by the public, and it is unlikely that all found carcasses are reported to salvage participants. In addition, only carcasses that are handled or sampled by salvage participants must be reported to the NOAA Sturgeon Salvage Program.

Atlantic sturgeon may also be affected by fuel oil spills resulting from vessel accidents. Fuel oil spills could affect Atlantic sturgeon and their prey . However, these spills typically involve small amounts of material with limited and localized impacts. Larger oil spills may result from severe accidents, although these events would be rare and involve small areas. No direct adverse effects on Atlantic sturgeon resulting from fishing vessel fuel spills have been documented.

Pollution

Anthropogenic sources of pollution, while difficult to attribute to a specific Federal, state, local, or private action, may affect Atlantic sturgeon in the action area. Sources of pollutants in the action area include atmospheric loading of pollutants such as PCBs; storm water runoff from coastal towns, cities, and villages; runoff into rivers emptying into bays; groundwater discharges; sewage treatment plant effluents; and oil spills. Nutrient loading from land-based sources, such as coastal communities and agricultural operations, is known to stimulate plankton blooms in closed or semi-closed estuarine systems. The effect to larger embayments is unknown. Contaminants could degrade habitat if pollution and other factors reduce the food available to Atlantic sturgeon.

State Management Programs

Virginia’s management programs provide protection for lands and waters in or near Atlantic sturgeon habitat. These include approved coastal management programs under the Coastal Zone Management Act and Clean Water Act as well as programs affecting land use that provide protection to Atlantic sturgeon and Atlantic sturgeon habitat by restricting activities that degrade water quality, alter water flows, or damage bottom habitat. Virginia’s Department of Environmental Quality administers state and federal laws and regulations for air quality, water quality, water supply and land protection. In addition, other programs cover a variety of environmental activities, such as improving the ability of businesses and local governments to protect the environment, and offering technical and financial assistance for air and water quality improvements. Virginia Department of Game and Inland Fisheries (VDGIF) is responsible for the management of inland fisheries, wildlife, and recreational boating in Virginia. The mission, in part, is to maintain optimum populations of all species and to provide outdoor recreational opportunities. The State Water Control Board promulgates Virginia's water regulations, covering a variety of permits, permit fees, ground water management areas, ground water withdrawals and petroleum storage tanks.

Education and Outreach Activities

Education and outreach activities are considered some of the primary tools that will effectively reduce the threats to all protected species. For example, NMFS has been active in public outreach to educate fishermen about handling and resuscitation techniques for sea turtles and sturgeon, and educates recreational fishermen and boaters on how to avoid interactions with these species. NMFS also has a program called “SCUTES” (Student Collaborating to Undertake Tracking Efforts for Sturgeon), which offers educational programs and activities about the movements, behaviors, and threats to sturgeon. NMFS intends to continue these outreach efforts in the action area in an attempt to reduce interactions with protected species, and to reduce the likelihood of injury to protected species when interactions do occur.

NMFS Research Permitted Activities

Research activities either conducted or funded by Federal agencies within the action area may adversely affect ESA-listed fish, and may require a section 7 consultation. NMFS has issued research permits under section 10(a)(1)(A) of the ESA, which authorizes activities for scientific purposes or to enhance the propagation or survival of the affected species. The permitted activities do not operate to the disadvantage of the species and are consistent with the purposes of the ESA, as outlined in section 2 of the Act. There is currently one section 10(a)(1)(A) permit for intentional collection of live Atlantic sturgeon in the James River. Guidelines developed by sturgeon researchers in cooperation with NMFS staff (Moser *et al.* 2000, Damon-Randall *et al.* 2010, Kahn and Mohead 2010) provide standardized research protocols that minimize the risk to sturgeon from capture, handling, and sampling. These guidelines must be followed by any entity receiving a federal permit to do research on Atlantic sturgeon.

NOAA’s Sturgeon Salvage Program operates under a third section 10(a)(1)(A) permit but it does not allow for the capture or collection of live Atlantic sturgeon in the wild. NOAA’s Sturgeon Salvage Program is a network of individuals qualified to retrieve and/or use sturgeon carcasses and parts for scientific research and education. All carcasses and parts are retrieved opportunistically and participation in the network is voluntary. Sturgeon carcasses can provide pertinent life history data and information on new or evolving threats. Their use in scientific research studies can reduce the need to collect live sturgeon.

Sturgeon Recovery Planning

Several conservation actions aimed at reducing threats to Atlantic sturgeon are currently ongoing. In the near future, NMFS will be convening a recovery team and drafting a recovery plan which will outline recovery goals and criteria and steps necessary to recover all Atlantic sturgeon DPSs. Numerous research activities are underway for sturgeon, involving NMFS and other Federal, state, and academic partners, to obtain more information on the distribution and abundance of sturgeon throughout their range, including in the action area. Efforts are also underway to better understand threats faced by sturgeon and ways to minimize these threats, including bycatch and water quality. Fishing gear research is underway to design fishing gear that minimizes interactions with Atlantic sturgeon while maximizing retention of targeted fish species. Several states are in the process of preparing ESA section 10 Habitat Conservation Plans aimed at minimizing the effects of state fisheries on Atlantic sturgeon.

8.0 CLIMATE CHANGE

The discussion below presents information relevant to consideration of climate change on the our consideration of the effects of the proposed action on Atlantic sturgeon. Climate change is relevant to the Status of the Species and Environmental Baseline sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion. Effects of the proposed action that are relevant to climate change are included in the Effects of the Action section below (Section 9.0 below).

In general, waters in the MidAtlantic are warming and are expected to continue to warm over time. Globally averaged surface ocean temperatures are projected to increase by approximately 0.7 °C by 2030 and 1.4 °C by 2060 compared to the 1986-2005 average (IPCC 2014[5]). Hare et al. (2016) assessed the vulnerability to climate change of a number of species that occur along the U.S. Atlantic coast. The authors define vulnerability as "the extent to which abundance or productivity of a species in the region could be impacted by climate change and decadal variability." Atlantic sturgeon were given a Vulnerability Rank of Very High (99% certainty from bootstrap analysis) as well as a Climate Exposure rank of Very High. Three exposure factors contributed to this score: Ocean Surface Temperature (4.0), Ocean Acidification (4.0) and Air Temperature (4.0). The authors concluded that Atlantic Sturgeon are relatively invulnerable to distribution shifts and that while the effect of climate change on Atlantic Sturgeon is estimated to be negative, there is a high degree of uncertainty with this prediction. Secor and Gunderson (1998) found that juvenile metabolism and survival were impacted by increasing hypoxia in combination with increasing temperature. Niklitschek and Secor (2005) used a multivariable bioenergetics and survival model to generate spatially explicit maps of potential production in the Chesapeake Bay; a 1oC temperature increase reduced productivity by 65% (Niklitschek and Secor, 2005). These studies highlight the importance of the availability of water with suitable temperature, salinity and dissolved oxygen; climate conditions that reduce the amount of available habitat with these conditions would reduce the productivity of Atlantic sturgeon. Changes in water availability may also impact the productivity of populations of Atlantic sturgeon in areas where water availability is limited. Spawning and rearing habitat may be restricted by increased salt water intrusion in rivers with dams or other barriers that limit access to upstream freshwater reaches; however, no estimates of the impacts of such change are currently available. Hare et al. conclude that most climate factors have the potential to decrease productivity (sea level rise; reduced dissolved oxygen, increased temperatures) but that understanding the magnitude and interaction of different effects is difficult. The effect of ocean acidification on Atlantic sturgeon over the next 30 years is predicted to be minimal.

Potential Effects of Climate Change in the Action Area

Climate change may affect the ecology of Chesapeake Bay and its tributaries, such as the James River, in a number of ways including further depression of dissolved oxygen levels, increased temperatures, decreases in oysters, eelgrass and dab species, and increases in cnidarians such as jellyfish (Mulholland *et al.* 2010). In 2008, the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC) reviewed the current understanding of climate change impacts on the tidal Chesapeake Bay and identified critical knowledge gaps and research priorities (Pyke *et al*. 2008). The report notes that the Bay is sensitive to climate-related forcings

---

[5] IPCC 2014 is used as a reference here consistent with NMFS 2016 Revised Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions (Available at: *https://www.fisheries.noaa.gov/national/endangered-species-conservation/endangered-species-act-guidance-policies-and-regulations*, last accessed September 2, 2020).

of atmospheric CO_2 concentration, sea level, temperature, precipitation, and storm frequency and intensity and that scientists have detected significant warming and sea-level-rise trends during the 20th century in the Chesapeake Bay. Climate change scenarios for CO_2 emissions examined by STAC suggest that the region is likely to experience significant changes in climatic conditions throughout the 21st century including increases in CO_2 concentrations, sea level rise of 0.7 to 1.6 meters, and water temperature increasing by up to 2° to 6°C. Changes in annual streamflow are highly uncertain, though winter and spring flows will likely increase. The report notes that changes in human activities over the next century have the potential to either exacerbate or ameliorate the predicted climatically induced changes. Given the uncertainty in precipitation and streamflow forecasts, the direction of some changes remains unknown; however, the report states that certain consequences appear likely, including rise in sea level in the Bay; increasing variability in salinity due to increases in precipitation intensity, drought, and storminess; more frequent blooms of harmful algae due to warming and higher CO_2 concentrations; potential decreases in the prevalence of eelgrass; possible increases in hypoxia due to warming and greater winter-spring streamflow; and, altered interactions among trophic levels, potentially favoring warm water fish and shellfish species in the Bay.

As a tributary of the Chesapeake Bay, the physical structure of the James River could be altered because of climate change and sea level rise. The Center for Coastal Research at the Virginia Institute of Marine Science (VIMS) indicates that several changes in coastal features may occur along the James River such as shifts in shallow subtidal and tidal marsh habitat (inundation), and shifts in submerged aquatic vegetation (SAV) (http://ccrm.vims.edu/research/climate_change/jmsph.html).

Additionally, salinity shifts, with increasing saline conditions in areas that were once brackish or fresh (Najjar *et al*. 2010), may occur. The James River is largely tidal fresh water habitat, and this could represent a significant change in habitat type and availability, especially for anadromous fish using the river. Shifts in salinity regimes may also alter the current biotic assemblages using the river, and the movement of saline dependent species into area~ further upstream may occur.

Rice *et al*. (2012) evaluated the effects of potential sea-level rise in the York and James Rivers. The models measured the effects of 30 cm, 50 cm, and 100 cm sea-level rises by 2100. The Three-Dimensional Hydrodynamic-Eutrophication Model (HEM-3D) was used to simulate tide, current and salinity for the Chesapeake Bay in order to facilitate the simulation of these same parameters for both rivers. The results of the model demonstrated that in all scenarios, a rise in salinity would be detected in these largely freshwater tidal rivers for much of the year. The effects of increased salinity would create larger issues in areas where estuarine stratification is greater (i.e. the James River). Clough and Larson (2010) ran a similar model, Sea Level Affecting Marshes Model (SLAMM 6) to examine the potential for marsh inundation at the James River National Wildlife Refuge. Using the model, they were able to predict that sea level may rise anywhere between 30-40 cm by 2062 and 40-70 cm by 2100.

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on Atlantic sturgeon. However, given the short period of time considered here (five years) we do not anticipate any changes to the distribution of Atlantic sturgeon in the action area related to climate change over the period considered here; we also do not anticipate any changes in the Status of the Species overall or in the action area or the effects of the Environmental Baseline due to climate change during this period.

9.0 EFFECTS OF THE ACTION

This section of the biological opinion assesses the effects of the proposed action on the Chesapeake Bay DPS of Atlantic sturgeon. Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR §402.02 and 402.17).

The effects of the proposed action are the effects of the issuance of an incidental take permit to Dominion. The proposed ITP would authorize incidental take of Chesapeake Bay DPS Atlantic sturgeon and require Dominion to implement the Conservation Plan to monitor, minimize, and mitigate, to the maximum extent practicable, impacts of the incidental taking that could occur as a result of CWIS operations at CPS, and completion of CWA 316(b) studies for the facility. The facility will continue to discharge effluent as a result of normal operations; potential effects to Atlantic sturgeon from the discharge of effluent include exposure to heated water and any pollutants in the discharge. Dominion has indicated that the operation of the facility is dependent on receiving deliveries of limestone and shipping out gypsum. These shipments occur by barge over water; potential effects to Atlantic sturgeon include interactions with these vessels as they transit to and from CPS to existing ports in the lower James River. These shipments occur monthly and are reasonably certain to occur over the five-year life of the proposed ITP. Dominion has indicated that dredging of the barge berth at CPS and shoreline maintenance activities are infrequent. Based on the information provided by Dominion, there are no permits or authorizations in place for such work during the 5 year permit period considered here, as such we do not consider these activities reasonably certain to occur during the permit window; consequently, any effects of future dredging and shoreline maintenance activities are not effects of the action and not considered in this consultation. If Dominion were to conduct these activities, they would require additional federal permitting and ESA consultation with the lead Federal agency authorizing or permitting any such activities.

9.1 Effects of Continued Operations of CPS Consistent with the Terms of the Proposed ITP

Here, we consider the impacts to the Chesapeake Bay DPS of Atlantic sturgeon from incidental take that would be authorized by NMFS' issuance of an ITP to Dominion in regard to cooling water intake operations at CPS, and completion of CWA 316(b) studies for the facility.

9.1.1 Entrainment resulting from CWIS Operation

Entrainment occurs when small aquatic life forms are carried into and through the cooling system during water withdrawals. Entrainment primarily affects small organisms with limited swimming ability that can pass through the screen mesh used on the intake systems. Once entrained, organisms pass through the circulating pumps and are carried with the water flow through the intake conduits toward the condenser units. They are then drawn through one of the many condenser tubes used to cool the turbine exhaust steam (where cooling water absorbs heat) and then enter the discharge canal for return to the James River. As entrained organisms pass through the intake they can be injured from abrasion or compression. Within the cooling system, they encounter physical impacts in the pumps and condenser tubing; pressure changes and shear stress throughout the system; thermal shock within the condenser; and exposure to chemicals, including chlorine and residual industrial chemicals discharged at the diffuser ports (Mayhew et al. 2000). Death can occur immediately or at a later time from the physiological effects of heat, or it can occur after organisms are discharged if stresses or injuries result in an inability to escape predators, a reduced ability to forage, or other impairments. Eggs and larvae are the only life stage of Atlantic sturgeon that are small enough to be entrained in the CWIS.

Eggs

Fall spawning for Atlantic sturgeon is believed to occur near Richmond, which is several miles upriver of CPS. Pre-fertilized Atlantic sturgeon eggs are less than 3 mm in diameter or, measured by volume, approximately 80-120 pre-fertilized eggs per milliliter (Van Eenennamann et al. 1996; Mohler 2003) and spawned over and very near hard bottom substrate with interstitial spaces. Viable eggs become sticky within minutes of fertilization and adhere to the substrate where they remain for the relatively short and temperature dependent period before hatching into yolk-sac larvae. Therefore, viable eggs are present only at the spawning site. Because spawning does not occur in the action area, viable eggs do not occur in the action area and therefore are not susceptible to entrainment. Non-viable eggs may theoretically be present downstream of the spawning site. However, CPS is not expected to entrain non-viable eggs because the circumstances by which an egg would be susceptible to entrainment at CPS are improbable and extremely unlikely to occur. To become entrained at CPS, a non-viable egg would need to float downriver from the spawning site, evade all predation, and float out of the main channel flow of the river and into the area of the cooling water intake flows for one of the CPS operating units. Based on the best available information, this scenario is extremely unlikely to occur. Sturgeon do not protect their eggs after spawning and, although not quantified, predation of eggs is likely common given the nutritional value of fish eggs, in general. Therefore, it is most likely that before a non-viable egg could ever reach CPS, it would either settle on the bottom, be carried away by the current but eventually caught among the interstitial spaces, or be either at the bottom or free floating in the current and eaten. Even in the unlikely circumstance that a non-viable sturgeon egg floated miles downriver to CPS, it would still need to be floating at the specific depth and in the specific proximity of CPS and the water intake flow for one of the CWISs in order for it to be entrained. This scenario is, likewise, extremely unlikely to occur given the large volume of water in the James River, and the distance of the cooling water intake structures from the main channel flow of the river. These conclusions are supported by the lack of any evidence of entrainment of sturgeon eggs at CPS in the past.

Larvae

Larvae are only considered potentially present in the area near the CWIS following fall spawning as they move downstream past CPS from the upstream spawning locations. As described in the

Status of the Chesapeake Bay DPS of Atlantic Sturgeon section, spring spawning has been detected downriver of CPS near Curles Neck Swamp which is situated in the Turkey Island oxbow (Balazik and Musick 2015). Fall spawning activity for the Chesapeake Bay DPS occurs August-October (Balazik *et al*. 2012, Hager *et al*. 2014, Balazik and Musick 2015, Richardson and Secor 2016) although the period of actual spawning may be shorter given that male sturgeon move to spawning areas before females (NMFS 2012). The collection of larvae at CPS in 2015 and the collection of over 300 Age-0 sturgeon downriver of CPS in 2018 (*Sturgeon Making a Comeback in the James River*, Chesapeake Bay Magazine, October 30, 2018) confirm that spawning that occurs upstream of CPS results in larvae moving downstream past CPS. Given their small size, Atlantic sturgeon larvae are vulnerable to entrainment at CPS.

Larvae smaller than 3/8 inch can pass through the screen mesh. Studies to characterize entrainment associated with CPS operations were conducted in 1977, 2005-2006 and 2015-2016. As reported by Dominion, no Atlantic sturgeon were captured during these studies except one sampling event during October 2015 when two Atlantic sturgeon yolk sac larvae were collected. It is reasonable to use past entrainment results to predict future effects. This is because the estimated interaction rate is based on sampling events during September and October in 2005 and 2015, the time when Atlantic sturgeon larvae are most likely to be in the vicinity of CPS. While the sampling that occurred in 1977 was conducted as part of a comprehensive study, we do not consider this sampling event in our analysis because after more than 40 years, it is unlikely to be representative of the current conditions that exist in the action area and no longer constitutes the best available scientific information.

The best available information indicates that entrainment of larvae at CPS is rare. As noted above, no Atlantic sturgeon larvae were documented in entrainment characterization studies in 1977 or 2005 and during the sampling carried out from 2015-2016, two individuals were collected. During the review period for Dominion's application, NMFS staff worked with Dominion to develop an estimate of likely future entrainment based on the limited, but best available information. As explained below, we anticipate entrainment of approximately 54,745 Chesapeake Bay DPS Atlantic sturgeon larvae as a result of cooling water intake operations at CPS over the course of the proposed 5-year ITP period at a rate of 1,820 to 33,789 larvae per year (annual average of 10,949 per year). This estimate is based on an evaluation of the documented past entrainment monitoring, documented collection of Atlantic sturgeon larvae in 2015 and available information on facility operations and intake volumes (see Table 9). We have reviewed the analysis presented in the revised ITP application and find it consistent with the recommendations made by NMFS' expert statistician's advice on developing this estimate. We have determined it is based on the best available scientific information and provides a robust estimate of the future entrainment that is reasonably certain to occur. Using these calculations, the annual take with an interaction rate of 0.000132423 (0.000022013-0.000408657) and 82.685 million cubic meters of water flow would be an average of 10,949 with a range of 1,820 to 33,789 larvae per year (Linden 2018).

Inputs/Outputs	Parameter/Estimate
Time interval used to estimate interaction rate	September and October 2005; September and October 2015
Volume of water sampled (m^3)	15,103
Time interval for forecast	5 years
Interaction rate of monitoring program (larvae per m^3)	0.000132423
Estimated flow over 6-week spawning period (m^3)	82,685,315
Estimated annual take for CPS CWIS operations (larvae)	10,949
Estimated take for CPS CWIS operations over 5-year period (larvae)	54,747

Table 8. Estimated Entrainment of Atlantic Sturgeon from CPS Cooling Water Intake from Dominion 2019

NMFS processed the ITP application using 10,949 as the average estimated annual take, however, we also consider the annual range that could occur taking into consideration the lower and upper ends of the 95% confidence interval. As previously stated, the total authorized take in the proposed permit is 54,747 larvae over a 5-year period. Based on the best available information, in any given year take by entrainment could range from 1,820 to 33,789 sturgeon larvae; however, over the five-year period we do not expect the total entrainment to exceed 54,747 larvae.

It is possible that some entrained larvae will survive; however, we expect that most, if not all, of the entrained larvae will die due to injuries suffered during entrainment. It is also possible that some larvae will be dead prior to entrainment. However, we do not have sufficient information to refine the amount of anticipated entrainment that would fall into these different categories. As such, and given the high mortality rate anticipated for entrained larvae, we expect that all of the entrained larvae will die. As explained above, entrainment of any other life stage is extremely unlikely to occur.

9.1.2 Predicted Future Effects resulting from Clean Water Act 316(b) Studies

We anticipate collection/entrainment of no more than one Chesapeake Bay DPS Atlantic sturgeon larvae as a result of CWA 316(b) entrainment studies. As more fully discussed in the *Description of the Proposed Action* section, the requested take in Dominion's ITP application is based on the interaction rate of larval Atlantic sturgeon in entrainment sampling conducted from September and October of 2005 and 2015. In order to complete the two-year, 316(b) sampling program, Dominion will collect at near-bottom depths for six months during September through December (See Table 4 in the *Description of the Proposed Action* section). Water volumes collected for sampling represent a subsample of CPS cooling water intake, so the volume of water at CPS does not increase because of CWA 316(b) sampling. As noted above, bottom samples during September and October have the potential to entrain Atlantic sturgeon larvae and result in the collection of individuals.

As with entrainment associated with CPS operations, it is reasonable to use past entrainment results to predict future effects. Dominion calculated an interaction rate of 0.000132423 Atlantic sturgeon larvae per cubic meter (m^3) of water sampled using September and October samples from 2005 and 2015. Based on the total number of proposed near-bottom samples (i.e., 16 samples) to be collected during the fall spawning season, approximately 1,600 m^3 of sample water will be collected, resulting in the take estimate of 0.21 Atlantic sturgeon larvae for the remaining 316(b) sampling program (Table 10). We have reviewed this take estimate and have determined it is based on the best available scientific information and results in a prediction of future collection of Atlantic sturgeon larvae that is reasonably certain to occur. Since a fraction of a sturgeon cannot be taken, take (collection/entrainment) of one Chesapeake Bay DPS Atlantic sturgeon larvae is anticipated as a result of Dominion's completion of 316(b) studies at CPS.

Input/Output	Value
Time interval used to estimate interaction rate	September and October 2005; September and October 2015
Estimated interaction rate (with 95 percent CI)	0.000132423
Expected number of samples (proposed)	16
Estimated take during the remainder of 316(b) sampling program	1

Table 9. Estimated Take of Atlantic sturgeon during remainder of 316(b) Entrainment Sampling

9.2 Effects of Mitigation Activities

Section 10(a)(1)(B) of the ESA specifies that no permit may be issued unless an applicant submits an adequate Conservation Plan. In the time since their 2017 ITP application submittal, Dominion has revised its proposed Conservation Plan, which describes measures designed to minimize, monitor, and mitigate the incidental take of Atlantic sturgeon. Dominion proposes to mitigate the anticipated impact of CPS cooling water intake operations on Chesapeake Bay Atlantic sturgeon through support for three lines of research: (1) genetic relationship research, (2) sturgeon movement research, and (3) a digital holography entrainment pilot study. Here, we consider the effects of the mitigation activities associated with implementation of the revised HCP on Atlantic sturgeon.

Genetic Relationship Research

Dominion proposes to provide any collected specimens of entrained Chesapeake Bay DPS Atlantic sturgeon eggs or larvae to Atlantic sturgeon researchers. Specimens would be preserved following protocols established to prevent damage to the genetic materials. NMFS and any previously approved potential recipients would be notified of the specimens and instructions for final disposition of the specimens, including handling and processing of any specimens and appropriate genetic analyses at an approved laboratory. It is reasonable to expect that the transfer of any Atlantic sturgeon specimens to NMFS or researchers for genetic testing would further research on the genetic relationships of early life stages occupying the James River and support filling knowledge gaps related to genetics or other aspects of life history. This mitigation activity would take advantage of incidentally collected early life stages. As such, no additional effects to Atlantic sturgeon beyond mortality that occurred because of entrainment will result from these research efforts.

Sturgeon Movement Research

Dominion proposes a partnership with the Virginia Commonwealth University (VCU) Rice Rivers Center to make use of data from real-time Vemco monitoring stations near the Rice Rivers Center and Sturgeon Point. VCU will provide Dominion access to the real-time tracking data for acoustically-tagged sturgeon that move upriver of CPS to spawn. An existing array of passive acoustic receivers in the James River has provided data describing Atlantic sturgeon movements in recent years. Dominion will contract with VCU to deploy and maintain additional, new, receivers downstream of the CPS facility in September through October for the duration of the ITP. This mitigation activity would take advantage of the large number of acoustically tagged Atlantic sturgeon already occupying the James River. It is reasonable to expect that this mitigation activity would provide information necessary for better assessing the risk of CPS operations. The objective of deploying additional receivers would be to gain an improved understanding of the behavior patterns of Atlantic sturgeon as they enter the reach of the James River theoretically influenced by CPS operations. Receivers would be placed to detect sturgeon in a manner that would enable assessment of sturgeon interactions with plant operations including vessel operations and water intakes. It is also reasonable to expect that this mitigation activity would provide additional evidence of seasonal patterns of movement that distinguish the size and behaviors of cohorts in the fall versus spring spawning migrations.

No effects to Atlantic sturgeon are anticipated to result from this mitigation activity. This is because this activity only involves monitoring previously tagged Atlantic sturgeon (several hundred Atlantic sturgeon have been captured and released with acoustic tags in the James River since 2009) and there are no effects to sturgeon from this type of passive monitoring. Tag detections in the existing receiver array are currently shared among all parties engaged in the Atlantic coast-wide network of Atlantic sturgeon researchers and managers. The tagging or collection of any sturgeon detected by these receivers would be carried out under the authorities of permits issued to researchers pursuant to Section 10 of the ESA.

Digital Holography Entrainment Pilot Study

Dominion proposes to implement a pilot study that utilizes real-time, in situ, digital holography to detect, count, and identify early life-stage Atlantic sturgeon at the CPS facility. Digital holography is an imaging technique that generates a hologram using an array of digital sensors and computer algorithms. The use of digital holography has provided marine scientists with an opportunity to record, non-intrusively and non-destructively high-resolution holograms of micro-objects (e.g. phyto- and zooplankton) in three dimensions in their natural environment (H. Sun *et al.* 2008). Dominion intends to test the system used in the pilot study against the previously proposed monitoring methods in an effort to compare results and improve the accuracy of the digital holography system. Dominion plans to obtain sufficient imagery (e.g., 1,000 – 2,000 images) of larval Atlantic sturgeon at various angles to develop an algorithm that will allow for identifying and counting in situ larvae, and deploying instrumentation at CPS concurrent with the ITP entrainment sampling program described in the “Description of the Proposed Action” section. It is reasonable to expect that, if effective, this mitigation activity would provide information to inform minimization measures for Atlantic sturgeon larvae and contribute to the development of a new method of real-time, non-lethal monitoring. No effects to Atlantic sturgeon are anticipated to result from this pilot study. This is because digital holography imaging will not interact with sturgeon.

9.3 Consideration of Other Effects of the Continued Operation of CPS

9.3.1 Impingement

Impingement at a rack or screen occurs when the intake velocity is high enough that individuals cannot swim away and are retained against the bars of the rack or on the screen. There are three locations where impingement of organisms (of various size) could occur at the CPS intakes: the intake guard, the trash racks, and the traveling screens. At CPS, trash racks are located in front of each intake structure and form a barrier to keep large debris away from the intake travelling screens. Upon approach, river water encounters the trash racks that extend to the bottom of the intake structure. A curtain wall that extends 4.0-4.5 feet below the water surface at all tide levels is immediately behind the trash racks in the upper portion of the water column. The travelling screens are located between 10 and 20 feet on the interior side of the trash racks. The trash rack bars at each unit are 0.375 inches. Placement of the bars at each unit varies from 3.0-4.5 inches on center. The traveling water screens are located 10-20 feet inside of the trash racks, and have 3/8 inch mesh. Impingement only occurs when a fish cannot swim fast enough to escape the intake (e.g., the fish's swimming ability is overtaken by the velocity of water being sucked into the intake). A few studies have been carried out to examine the swimming ability of sturgeon and their vulnerability to impingement. Generally speaking, fish swimming ability, and therefore ability to avoid impingement and entrainment, are affected not just by the flow velocity into the intakes, but also fish size and age, water temperature, level of fatigue, ability to remain a head-first orientation into current, and whether the fish is sick or injured.

Kynard et al. (2005) conducted tests in an experimental flume of behavior, impingement, and entrainment of yearlings (minimum size tested 280mm FL, 324mm TL), juveniles (minimum size tested 516mm FL, 581mm TL) and adult shortnose sturgeon (minimum size tested 600mmFL, 700mm TL). Impingement and entrainment were tested in relation to a vertical bar rack with 2 inch clear spacing. The authors observed that after yearlings contacted the bar rack, they could control swimming at 1 and 2 fps, but many could not control swimming at 3 fps velocity. Afeeter juveniles or adults contacted the rack, they were able to control swimming and move along the rack at all three velocities. During these tests, no adults or juveniles were impinged or entrained at any approach velocity. No yearlings were impinged at velocities of 1 fps, but 7.7-12.5% were impinged at 2 fps, and 33.3-40.0% were impinged at 3 fps. The range of entrainment of yearlings (measured as passage through the rack) during trials at 1, 2, and 3 fps approach velocities follow: 4.3-9.1% at 1 fps, 7.1-27.8% at 2 fps, and 66.7-80.0% at 3 fps. From this study, we can conclude that shortnose sturgeon that are yearlings and older (at least 280mm FL) would have sufficient swimming ability to avoid impingement at an intake with velocities of 1 fps or less, as long as conditions are similar to those in the study (e.g., fish are healthy and no other environmental factors in the field, such as heat stress, pollution, and/or disease, operate to adversely affect their swimming ability).

The swimming speed that causes juvenile shortnose sturgeon to experience fatigue was investigated by Deslauriers and Kieffer (2012). Juvenile shortnose sturgeon (19.5 cm average total length) were exposed to increasing current velocities in a flume to determine the velocity that caused fatigue. Fish were acclimated for 30 minutes to a current velocity of 5 cm/sec (0.16 fps). Current velocities in the flume then were increased by 5 cm/sec increments for 30 minutes per increment until fish exhibited fatigue. Fish were considered fatigued when they were impinged on the down-stream plastic screen for a period of 5 seconds (Deslauriers and Kieffer (2012).

The current velocity that induced fatigue was reported as the critical swimming speed ("U_{crit}") under the assumption that the fish swam at the same speed as the current. The effect of water temperature on U_{crit} for juvenile shortnose sturgeon was determined by repeating the experiment at five water temperatures: 5°C, 10°C, 15°C, 20°C and 25°C. Shortnose sturgeon in this study swam at a maximum of 2.7 body lengths/second (BL/s) at velocities of 45 cm/s (1.47 fps). In this study, the authors developed a prediction equation to describe the relationship between Ucrit and water temperature. The authors report that amongst North American sturgeon species, only the pallid and shovelnose sturgeon have higher documented U_{crit} values (in BL/s) than shortnose sturgeon at any given temperature.

Boysen and Hoover (2009) conducted swimming performance trials in a laboratory swim tunnel with hatchery-reared juvenile white sturgeon to evaluate entrainment risk in cutterhead dredges. The authors observed that 80% of individuals tested, regardless of size (80-100mm TL) were strongly rheotactic (i.e., they were oriented into the current), but that endurance was highly variable. Small juveniles (< 82 mm TL) had lower escape speeds (< 40 cm/s (1.31fps)) than medium (82–92 mm TL) and large (> 93 mm TL) fish (42–45 cm/s (1.47 fps)). The authors concluded that the probability of entrainment of juvenile white sturgeon could be minimized by maintaining dredge head flow fields at less than 45 cm/s (1.47 fps).

Hoover et al. (2011) used a Blazka-type swim tunnel, to quantify positive rheotaxis (head-first orientation into flowing water), endurance (time to fatigue), and behavior (method of movement) of juvenile sturgeon in water velocities ranging from 10 to 90 cm/s (0.3-3.0 fps). The authors tested lake and pallid sturgeon from two different populations in the U.S. Rheotaxis, endurance, and behavioral data were used to calculate an index of entrainment risk, ranging from 0 (unlikely) to 1.00 (inevitable), which was applied to hydraulic models of dredge flow fields. The authors concluded that at distances from the draghead where velocity had decreased to 40cm/s (1.31 fps) entrainment was unlikely.

Consideration of Potential for Impingement on the Intake Guards
Following the impingement of four adult Atlantic sturgeon in September 2018, Dominion completed an underwater survey of the intake guards. During the survey it was discovered that most of the intake guards were degraded, and in one case missing. As a result of the survey, Dominion submitted an application to the USACE and Virginia Marine Resources Commission on February 8, 2019, to repair and/or replace the CPS intake guards. Following the issuance of the USACE permit, intake guards for Units 3, 4, and 8 were removed and replaced. The Unit 5 and 6 intake opening was expanded to reduce water velocities and new intake guards were installed. The installation of intake guards in front of CWIS structures 3, 4, 5, 6, and 8 was completed as of April 2019. Dominion determined that the intake guard for Unit 7 did not need to be modified, as it met the new design criteria.

As part of the intake guard renovations, grid openings were reduced from approximately 12 inches on center to 8 inches on center. The grid openings of the intake guards were designed to prevent the smallest adult Atlantic sturgeon in the James River from entering the CWIS structure. The opening size was developed in coordination with Dr. Balazik and, based on specimens collected as part of the VCU Atlantic sturgeon research program (Balazik pers. comms.).

Only adult Atlantic sturgeon are large enough to be potentially impinged on the intake guards. Here, we consider the potential for impingement of adult Atlantic sturgeon on the intake guards. Considering the reported velocity at the intake guards (0.79 fps, 0.84 fps, 1.01 fps, 0.74 fps, and 0.67 fps for Units 4, 5, 6, 7, and 8 respectively), and that velocity has dissipated to 0.5 fps at a distance of 69 feet from any of the intakes, and assuming conditions similar to those in laboratory studies cited above, we would not anticipate any impingement of Atlantic sturgeon at the trash racks. That is because sturgeon that are big enough to avoid passing through the racks would be adults. These fish are able to avoid impingement at velocities of up to 3 feet per second and should be able to readily avoid getting stuck on the intake guards which have an intake velocity of no more than 0.5 fps at a distance of 69 feet from the intake and 0.67-1.01 fps at the face of the intake. It is possible that post-spawn adults may be tired or stressed and more vulnerable to impingement than the adults considered in the laboratory studies cited above, however, given that the velocities expected at the intake guards are low enough that even smaller juveniles would be expected to be able to avoid impingement and are less than 1/3 of the velocity that an adult is expected to be able to readily avoid, we expect that even a tired post-spawned adult would be able to readily avoid impingement. Further, given that the intake velocity is well below the expected critical swim speed (at least 2.7 body lengths/second) of adult Atlantic sturgeon, we expect adults to be able to avoid impingement even during high river flows.

Based on the information available, we have determined that impingement of adult Atlantic sturgeon at the guards is extremely unlikely to occur.

Consideration of Impingement on the Trash Racks

In order to be impinged on the trash racks, a sturgeon would need to be small enough to pass through the intake guards but be too big to pass through the trash racks. The only Atlantic sturgeon that fit into that size category are large juveniles or subadults. As established above, these lifestages do no not occur in the vicinity of the intake. As such, any such impingement is extremely unlikely to occur.

Consideration of Impingement on the Traveling Screens

In order to be impinged on, or collected in, the traveling screens, Atlantic sturgeon need to be small enough to swim through the trash bars but too big to pass throughthe screen openings. The only such Atlantic sturgeon are small juveniles or young of year. As explained above, these life stages are not known to occur in the vicinity of the intake. As such, any such impingement is extremely unlikely to occur. The lack of any documented impingement of Atlantic sturgeon at the traveling screens in the past supports this conclusion.

NMFS received comments on the draft ITP and Conservation Plan in which the commenter suggested that a dredged channel in front of the CWIS increased the risk of impingement and entrainment. We have considered the information presented and find that the conclusions reached above remain valid. This is because there is no evidence to support the claim that post-spawn adults are too weak to avoid diversion into the CWIS flow. Balazick *et al*. 2020 described swim behavior and swimming speeds for pre- and post-spawning sturgeon during the fall 2017 season. Based on real-time receivers around hypothesized spawning habitat, most telemetered male Atlantic sturgeon stayed around spawning habitat for weeks after the peak spawning season (September 5 to 14) but started migrating downstream in early October. Individual movement analysis indicated that Atlantic sturgeon swim speed and meandering (i.e. deviations from a straight swam path) did not vary significantly between upstream and downstream movements (Balazick *et al.* 2020). Moreover, catch and telemetry data show migrating adults have a high affinity for deep channels (Reine *et al.* 2014, Balazick *et al*. 2020). Based on the river depths immediately adjacent to the CWISs (29 to 33 feet) in comparison to water depths in the center of the river (44.1 to 50.9 feet), we do not expect post spawn adults to deviate into the dredge channel at the CWIS from their swim path downstream in the main channel. The commenters presented no information to support their claim and given the information on the zone of influence of the intakes and the associated velocity (i.e., intake velocity dissipates to 0.5 fps within 69 feet of the intake, a velocity that is considered to be readily avoidable by adult sturgeon), it is not reasonable to conclude that the dredged channel increases the risk of impingement. Even if these adults did swim into the dredge channel, the velocity at the intakes is well below that shown to create a risk of impingement for even young sturgeon; thus, as noted above, impingement of post-spawn adults is extremely unlikely to occur.

Regarding any potential increased risk of larval entrainment due to the presence of the dredged channel, we do not expect larvae to deviate from the main channel as they move downstream past CPS. Hard-bottom substrate suitable for foraging and refuge for Atlantic sturgeon larvae is present in the vicinity of CPS. This stretch of the James River begins its transition from a steep banked, narrow-channeled river to a classical meandering river with oxbows (VEPCO 2000). As stated above, CPS intakes are not located in a river bend where the deepest part of the channel is on the outside of the bend (meaning closest to intakes). Instead, water depths in the vicinity of the intakes are more shallow than water depths in the center of the river. There is no evidence to support the commenter's claim that larvae will be diverted from the main channel because of the innate behavioral drive of sturgeon larvae to go with the current created by the dredged side channels leading to the CWIS. This claim assumes that larvae will always be in a state of passive drift as they move past CPS. As Atlantic sturgeon embryos develop into larvae, depletion of the yolk-sac and onset of exogenous feeding is accompanied by increased motility and a preference for open areas approximately 1m above the bottom (Kynard and Horgan 2002). However, based on ontogenetic behavioral studies, Atlantic sturgeon larvae engage in active swimming and bottom foraging in addition to "swim-up and drift" movements during downstream migrations. Movements between different zones of the river channel facilitate access to different bottom substrates that allow larvae to act on the innate behavioral drives to also avoid predation risks and starvation as they migrate (Kynard and Horgan 2002, Gessner *et al*. 2009). The commenters presented no information to support their claim and given the information on the zone of influence of the intakes and the associated velocity (i.e., intake velocity dissipates to 0.5 fps within 69 feet of the intake) and the lack of any information to indicate that the dredged channel results in an increased area of influence or diverts migrating larvae to the intakes. Because of this we do not agree that the dredged channel increases the risk of larval entrainment. Furthermore, CWA316(b) studies were completed throughout the fall of 2015, as noted above these samples were found to contain only two yolk-sac larvae. If the commenter's claims that the risk of entrainment is higher than is characterized here was true, we expect that significantly more larvae would have been present in the samples collected during this period.

9.3.2 Effects of Impingement and Entrainment on Atlantic Sturgeon Prey

Atlantic sturgeon feed primarily on benthic invertebrates. As these prey species are found on the bottom and are generally immobile or have limited mobility and are not within the water column, they are less vulnerable to impingement or entrainment. In the past, CWA 316(b) Impingement Mortality and Entrainment Characterization studies at CPS have not included macroinvertebrates as focus species (EA 2007). However, given the life history characteristics (sessile, benthic, not suspended in or otherwise occupying the water column) of Atlantic sturgeon forage items which make impingement and entrainment unlikely, any loss of sturgeon prey due to impingement or entrainment is likely to be minimal. Therefore, we have determined that the effects on Atlantic sturgeon due to the potential loss of forage items caused by impingement or entrainment in the CPS CWIS intakes are likely to be so small that they can not be meaningfully measured, evaluated, or detected and effects are insignificant.

9.3.3 Effects of Discharges to the James River

The discharge of pollutants from the CPS facility is regulated for CWA purposes through the Virginia VPDES program. The VPDES permit (VA0004146) specifies the discharge standards and monitoring requirements for each discharge. Under this regulatory program, CPS treats wastewater effluents, collects and disposes of potential contaminants, and undertakes pollution prevention activities. As currently configured, CPS cannot operate without withdrawing water from and discharging water to the James River. Therefore, effects of the proposed action include the discharge of effluent to the James River. The effects of the CPS facility continuing to operate under the terms of the existing licenses and under the terms of the 2016 VPDES permit will be discussed below.

9.3.3.1 Thermal Tolerances - Atlantic Sturgeon

Limited information on the thermal tolerances of Atlantic sturgeon is available. Juvenile Atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010; ASMFC 2017) and adult Atlantic sturgeon have been documented in waters as warm as 33.1 in South Carolina (ASMFC 2017) and as high as 30C in the James River (Balazik et al. 2012).

In the laboratory, both shortnose and Atlantic sturgeon larvae survived considerably longer at lower rearing temperatures (13°C and 15°C), with mortality increasing rapidly following the full absorption of the yolk. The acceleration of mortality in yolk-sac larvae in higher temperatures is often attributed to higher metabolic rates, which result in faster absorption of endogenous energy sources (Kamler 1992). Laboratory studies involving juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). These tests were carried out with fish reared at the U.S. Fish and Wildlife Service's Northeast Fishery Center (Lamar, PA) and are progeny of Hudson River broodstock. It is important to note that there may be physiological differences in sturgeon originating from different river systems. Fish originating from southern river systems may have different thermal tolerances than fish originating from northern river systems. For purposes of considering behavioral and bioenergetics responses, Hudson River (i.e. New York Bight DPS) sturgeon are a reasonable surrogate for Chesapeake Bay DPS Atlantic sturgeon given known physiological similarities. Thus, it is reasonable to rely on results of this study when considering thermal tolerances of Atlantic sturgeon in the James River.

Tolerance to temperatures is thought to increase with age and body size (Ziegweid *et al.* 2008 and Jenkins *et al.* 1993); however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. For purposes of considering effects of thermal tolerances, shortnose sturgeon are a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities.

Ziegeweid et al. (2008a) conducted studies to determine critical and lethal thermal maxima for young-of-the-year (YOY) shortnose sturgeon acclimated to temperatures of 19.5 and 24.1°C (67.1 – 75.4°F). These studies were carried out in a lab with fish from the Warm Springs National Fish Hatchery (Warm Springs, Georgia). The fish held at this fish hatchery were reared from broodstock collected from the Altamaha and Ogeechee rivers in Georgia. Lethal thermal maxima were 34.8°C (±0.1) and 36.1°C (±0.1) (94.6°F and 97°F) for fish acclimated to 19.5 and 24.1°C (67.1°F and 75.4°F), respectively. Acclimation temperatures of 19.5 and 24.1°C are similar to the temperatures where adult Chesapeake Bay DPS Atlantic sturgeon make rapid movements between sites likely searching for other adults (i.e. a spawning congregation) (13° to 26°C)(Hager 2011) suggesting that this it is reasonable to rely on these results for assessing effects to James River sturgeon. As stated above, there may be physiological differences in sturgeon originating from different river systems. However, the information presented in this study is currently the best available information on thermal maxima and critical temperatures for shortnose sturgeon. The study also used thermal maximum data to estimate upper limits of safe temperature, final thermal preferences, and optimum growth temperatures for YOY shortnose sturgeon. Visual observations suggest that fish exhibited similar behaviors with increasing temperature regardless of acclimation temperature. As temperatures increased, fish activity appeared to increase; approximately 5–6°C (9-11°F) prior to the lethal endpoint, fish began frantically swimming around the tank, presumably looking for an escape route. As fish began to lose equilibrium, their activity level decreased dramatically, and at about 0.3°C (0.54°F) before the lethal endpoint, most fish were completely incapacitated. Estimated upper limits of safe temperature (ULST) ranged from 28.7 to 31.1°C (83.7-88°F) and varied with acclimation temperature and measured endpoint. Upper limits of safe temperature (ULST) were determined by subtracting a safety factor of 5°C (9°F) from the lethal and critical thermal maxima data. Final thermal preference and thermal growth optima were nearly identical for fish at each acclimation temperature and ranged from 26.2 to 28.3°C (79.16-82.9°F). Critical thermal maxima (the point at which fish lost equilibrium) ranged from 33.7 (±0.3) to 36.1°C (±0.2) (92.7-97°F) and varied with acclimation temperature. Ziegeweid et al. (2008b) used data from laboratory experiments to examine the individual and interactive effects of salinity, temperature, and fish weight on the survival of YOY shortnose sturgeon. Survival in freshwater declined as temperature increased, but temperature tolerance increased with body size. The authors conclude that temperatures above 29°C (84.2°F) substantially reduce the probability of survival for YOY shortnose sturgeon. However, previous studies indicate that juvenile sturgeons achieve optimum growth at temperatures close to their upper thermal survival limits (Mayfield and Cech 2004; Allen et al. 2006; Ziegeweid et al. 2008a), suggesting that shortnose sturgeon may seek out a narrow temperature window to maximize somatic growth without substantially increasing maintenance metabolism. Ziegeweid (2006) examined thermal tolerances of YOY shortnose sturgeon in the lab. The lowest temperatures at which mortality occurred ranged from 30.1 – 31.5°C (86.2-88.7°F) depending on fish size and test conditions. For shortnose sturgeon, dissolved oxygen (DO) also seems to play a role in temperature tolerance, with increased stress levels at higher temperatures with low DO versus the ability to withstand higher temperatures with elevated DO (Niklitchek 2001). Given the physiological similarities between Atlantic and shortnose sturgeon we assume that a similar relationship exists for Atlantic sturgeon.

9.3.3.2 Effects of Thermal Discharge on Atlantic Sturgeon

Heated effluent is discharged into Farrar Gut and the mainstem James River. Temperatures are highest at the point of discharge and then dissipate as the heated effluent mixes with river water, creating a temperature gradient from the discharge point to where temperatures return to ambient; there is also a temperature gradient from the surface to the bottom, with the warmest waters being closest to the surface. Atlantic sturgeon are not known to occur in Farrar Gut; thus, we do not expect any Atlantic sturgeon to be exposed to increased water temperatures in Farrar Gut. The analysis here will focus on the effects of the thermal plume on larval and adult Atlantic sturgeon in the mainstem James River. The CWA 316(a) demonstration study described in the *Heated Effluent* section made extensive use of comparisons between conditions found from April 1997 to February 1999 with those reported from 1968-1971 in Jenson (1974). The analysis here is supplemented by later work using water quality analyses based on 90th percentile annual river water and effluent temperatures (see VPDES 2016), as well as temperature data collected over eight years (2008-2015) during fall (August-October) gill netting surveys in the freshwater portion of the James River (Balazick *et al.* 2012b, Balazick and Musick 2015).

The only months of the year that we expect Atlantic sturgeon to be passing by CPS and potentially exposed to the thermal plume are August – October (adults), with larvae only expected to occur in September and October. The available information indicates that during summer months (June-August) for the period 1991-1999, BTU heat rejection was its highest due to maximum operating conditions at the facility (i.e. 70-96% of capacity at Units 4,5, and 6)(VEPCO 2000). We note that Unit 4 has been retired; thus, the characterization of the thermal plume is expected to overestimate current conditions. Based on 90th-percentile temperature data for CPS outfalls, effluent is discharged at 45°C and 51.7°C at Outfall 001 and 003, to the James River and Farrar Gut respectively. Based on temperature data collected at five sampling stations located in the "CPS mixing zone" in mainstem James River in August 1997, surface temperatures ranged from 29.1-37.1°C (0.7-3.3°C above ambient) during low water slack surveys. During high water slack surveys, surface temperatures ranged from 29.1-31.1°C (0.3-2.1°C above ambient). In the next year (August 1998), surface temperatures during low water slack surveys ranged from 29.1-37.1°C (1.1-7.1°C above ambient). During high water slack surveys, surface temperatures in the mixing zone ranged from 31.1-33.1°C (0.3°C below ambient to 3.7°C above ambient). An examination of the benthic data for August 1997 revealed that the average bottom temperature at one mainstem James River sampling location within the CPS mixing zone downstream of Farrar Gut was 34.9°C (4.7°C above ambient). In August 1998, the average bottom temperature at this sampling location was 32.3°C (1.1°C above ambient) (VEPCO 2000).

In October 1997, surface temperatures in the mixing zone ranged between 25.1-29.1°C (0.1-4.6°C above ambient) during low water slack surveys. During high water slack surveys, temperatures ranged between 17.1-21.1°C (2.1-4.8°C above ambient). In October 1998, surface temperatures ranged between 17.1-23.1°C (0.2-2.7°C above ambient) during low water slack surveys. During high water slack surveys, average surface temperatures were approximately 25.1°C (1.7-2.6°C above ambient) at all five sampling stations in the mixing zone. Benthic data for October revealed that the average bottom temperatures at the mainstem James River sampling location within the mixing zone were 24.25°C (2.19°C above ambient) and 21.5°C (2.9°C above ambient) in 1997 and 1998 respectively. We were unable to identify any temperature monitoring for September; thus, for the purposes of this consultation we assume that water temperatures in September are similar to those reported for October.

Surface temperature values were selected for the CWA 316(a) demonstration studies because they represent maximum values measured in the surveys (VEPCO 2000). Thermal data for both surface and bottom water indicate that overall river temperatures vary from season to season, and from year to year. These data also demonstrate that the tidal cycle influences the thermal plume, confining it to Farrar Gut on the incoming tide and extending it downriver on the outgoing tide.

Larvae

The best available information indicates that Atlantic sturgeon larvae occur in the bottom meter of the water column. During the September and October period when larvae would be moving downstream past CPS, the thermal discharge increases water temperatures within the mixing zone. Water temperatures in the mixing zone of the James River are influenced by ambient river temperatures (which are expected to decrease over the September – October period as the weather cools) and the discharge of heated effluent from Outfall 001. The available monitoring information indicates that water temperatures near the bottom are at least occasionally warmed above ambient due to the discharge. Data from August suggest that bottom water temperatures in some portions of the mixing zone would at least occasionally be above the thermal tolerance for sturgeon larvae (24.5°C, ASMFC 2012) while information for October indicate that temperatures are not likely to be elevated above this level. As noted above, there is no information on bottom water temperatures for September; however, as ambient river temperatures cool between August and October it is reasonable to expect that conditions will be between those recorded for August and October. As such, it is possible that in the early parts of September there may be areas of the mixing zone with temperatures above the thermal tolerance of Atlantic sturgeon larvae; however, the bottom oriented nature of these larvae, their preference for the deepest part of the channel, their swim up and drift behavior that allows them to select preferred habitats, and the very short period of time that larvae would spend moving through the mixing zone makes exposure to these elevated temperatures extremely unlikely. It is important to note that by October, even with CPS operating at maximum capacity, average bottom temperatures remained within the tolerance range for this life stage (i.e., less than 24.5°C). Thus, while it is possible that there may be portions of the mixing zone, particularly closest to the outfall, where water temperatures are elevated above the thermal tolerances for larvae during the earliest part of the seasonal period when Atlantic sturgeon larvae may move past CPS, during the majority of the period when movement is likely to occur, temperatures are within the thermal tolerance of this life stage. Based on this analysis, effects to larval Atlantic sturgeon from the thermal effluent are extremely unlikely to occur.

Adults

The lab studies discussed in the *Thermal Tolerances* section above, indicate that thermal preferences and thermal growth optima for YOY shortnose sturgeon range from 26.2 to 28.3°C (79.2-83°F). This is consistent with field observations which correlate movements of shortnose sturgeon to thermal refuges when river temperatures are greater than 28°C (82.4°F) in the Altamaha River. Lab studies (see above; Ziegeweid *et al*. 2008a and 2008b) indicate that thermal maxima for shortnose sturgeon are 33.7 (±0.3) – 36.1(±0.1) (92.7-97°F), depending on endpoint (loss of equilibrium or death) and acclimation temperature (19.5 or 24.1°C). Upper limits of safe temperature were calculated to be 28.7 – 31.1°C (83.7-88°F). At temperatures 5-6°C (9-11°F) less than the lethal maximum, shortnose sturgeon are expected to begin demonstrating avoidance behavior and attempt to escape from heated waters; this behavior would be expected when the upper limits of safe temperature are exceeded. For purposes of this consultation, we will consider these threshold temperature values to also apply to adult Atlantic sturgeon. We use these thresholds to consider the potential for adult Atlantic sturgeon moving past CPS to be exposed to temperatures that could result in mortality and then consider if the thermal plume could act as a barrier to upstream or downstream movements.

Potential for Exposure to Lethal Temperatures

We first consider the potential for sturgeon to be exposed to temperatures that could result in mortality. To be conservative, we considered mortality to be likely at temperatures that are expected to result in loss of equilibrium (33.7±0.3 for fish acclimated to temperatures of 19.5°C and 36.1±0.2 for fish acclimated to temperatures of 24.1°C). As noted above, adult Chesapeake Bay DPS Atlantic sturgeon make rapid movements between sites in areas where temperatures range from 13° to 26°C (Hager 2011) suggesting that use of temperatures for fish acclimated to temperatures of 24.1°C is reasonable.

Based on the available information on the thermal plume, CPS discharges could raise surface river temperatures above 33.7°C in August if the facility is operating in the range of 94% of capacity during a low water slack tide. Given the current operating conditions at CPS and Dominion’s predicted future operations at the facility (i.e., approximately 60% of the DIF), surface river temperatures above 33.7°C represent a conservative estimate of the thermal impacts. Bottom temperature data for August under these conditions indicated that the average temperature in the mixing zone was 32.3°C during a high water slack tide, compared to 34.9°C on a low water slack tide. To be outside of those lethal temperatures during low water, fish need to be downstream of the facility in the vicinity of the Jones Neck oxbow or upstream past Outfall

001. Surface temperature data for August during the high water slack tide indicated that discharge did not raise river temperatures above 33.7°C. In October, river temperatures remained below 33.7°C regardless of tidal phase (VEPCO 2000).

Atlantic sturgeon are known to move to deep cool water areas during the summer months in southern rivers. Laboratory studies using Atlantic sturgeon (progeny from Hudson River broodstock) demonstrate that these species are able to identify and select between water quality conditions that significantly affect growth and metabolism, including temperature (Niklitschek 2001). Based on field observations and laboratory studies, we expect that sturgeon would actively avoid areas where temperatures are intolerable. It is reasonable to assume a gradual gradient because temperatures are highest at the point of discharge and then dissipate as the heated effluent mixes with river water, creating a temperature gradient from the discharge point to where temperatures return to ambient; there is also a temperature gradient from the surface to the bottom, with the warmest waters being closest to the surface. Because there is a gradient of temperatures decreasing with distance from Outfall 003 (VEPCO 2000), we expect Atlantic sturgeon to be able to detect the increase in temperature and avoid exposure to any temperatures at which prolonged exposure could be stressful or result in mortality. We do not expect individuals to remain within the heated surface waters to swim towards the outfalls and be exposed to temperatures which could result in mortality. As such, given that temperature decreases with distance from the outfall (due to mixing with cooler ambient river water which dissipates the heated effluent), sturgeon will be able to detect changes in temperature (i.e., that there is a gradual gradient of temperatures decreasing with increasing distance from the outfall as reported in VEPCO 2000) and escape from the area prior to prolonged exposure to critical temperatures, it is extremely unlikely that any sturgeon would remain within the area where surface temperatures are elevated to 33.7°C (92.7°F) and be exposed to potentially lethal temperatures. Similarly, as warmer water is less dense than cooler water and temperatures will decrease from surface to bottom, the vertical gradient of temperatures that decreases from the surface to the bottom is also expected to deter sturgeon from moving high enough up into the water column to encounter surface waters that have stressful or lethal temperatures. This risk is further reduced by the limited amount of time Atlantic sturgeon spend near the surface, the small area where such high temperatures will be experienced and the gradient of warm temperatures extending from the outfalls. It is important to note that this analysis is dependent on the assumption that exposure to increased temperatures will be gradual; that is, we do not anticipate that sturgeon would be exposed to rapid changes in water temperature; this is consistent with the best available information on the heated effluent. Based on this analysis, it is extremely unlikely that any adult Atlantic sturgeon will be exposed to water temperatures that would be lethal; rather, we expect adult Atlantic sturgeon to avoid areas with potentially lethal water temperature by swimming under or around such waters or in extreme circumstances, holding below the Jones Neck oxbow until conditions improve.

We received a letter from the Southern Environmental Law Center dated October 1, 2020 with information documenting fish kills that occurred in Farrar Gut on June 30, 2020 and August 7, 2020. We note that this is in addition to information on fish kills in Farrar Gut that was included with public comments on the draft ITP and information that is available in various news sources. We examined all available information on fish kills in Farrar Gut and found that there is no evidence of any sturgeon killed or even observed during those events. We considered the information presented in the letter and find that the conclusions reached above remain valid. Electrofishing and gillnetting surveys conducted in Farrar Gut have indicated that gizzard and threadfin shad (>60% of the total electrofishing catch at Farrar Gut) are attracted to the chronically elevated temperatures in Farrar Gut in the winter and repelled by these conditions in the heat of the summer (VEPCO 2000). We expect James River fishes to avoid water temperatures in excess of 35°C, however the July 1998 gillnet survey produced some fish (gizzard shad, white perch, catfish) in water temperatures between 40° to 42°C. Many fish species have been observed to make short-term feeding forays into waters warmer than their sustained thermal tolerances (Langford 1990, Brown 1974, VEPCO 2000). We do not expect any sturgeon to be forging in this area or to deviate from their direct upstream or downstream navigation path as they move past Farrar Gut in the mainstem of the James River. Therefore, while we acknowledge that the thermal discharge may result in the death of fish in Farrar Gut, we note that there is no evidence that any sturgeon have been killed as a result of discharge of heated effluent from CPS.

Potential for Disruption to Up or Downstream Movements
As noted above, we have determined that no Atlantic sturgeon adults are likely to be killed as a result of exposure to heated effluent. There is some information to suggest that Atlantic sturgeon may avoid water temperatures greater than 28°C (82.4°F) given that these temperatures have been demonstrated to be stressful to Atlantic sturgeon in lab settings. However, it is important to note that adults in the James River have been collected at temperatures up to 30C suggesting that temperatures of 28C may not limit movements of adults past CPS. Available information from field observations (primarily in southern systems; however this may be related to the prevalence of temperatures greater than 28°C in those areas compared to the rarity of ambient temperatures greater than 28°C in northern rivers) and laboratory studies (using progeny of fish from southern and northern rivers) suggests that water temperatures of 28°C (82.4°F) or greater can be stressful for juvenile sturgeon. This temperature (28°C; (82.4°F)) is close to both the final thermal preference and thermal growth optimum temperatures that Ziegeweid et al. (2008) reported for juvenile shortnose sturgeon acclimated to 24.1 °C (75.4 °F), and thus is consistent with observations that optimum growth temperatures are often near the maximum temperatures fish can endure without experiencing physiological stress. Based on the available information, we have conservatively considered that at least some Atlantic sturgeon will actively avoid areas with temperatures greater than 28°C.

As air temperatures begin to warm in the spring, the river temperatures do likewise; this trend continues into the summer. As temperatures begin to moderate, and decrease in the fall, river temperatures demonstrate the same trend (VEPCO 2000). Comparisons of available thermal data between years indicate that, during summer and early-fall months (August – September) ambient river temperatures at the surface and bottom can be warmer than 28°C and can also be high enough that temperature increases due to the influence of the thermal plume would cause water temperatures in excess of 28°C (VEPCO 2000, VPDES 2016). Atlantic sturgeon exposure to the surface area where water temperature would be elevated above 28°C (82.4°F) due to the influence of the thermal plume is limited by their normal behavior as benthic-oriented fish, which results in limited occurrence near the water surface. Because there is a gradient of water temperatures that decreases with increasing distance from CPS outfalls and decreases with depth from the surface, any surfacing Atlantic sturgeon are likely to detect the increase in water temperature and swim away from near surface waters with temperatures greater than 28°C. Reactions to this elevated temperature are expected to consist of swimming away from heated surface waters by traveling deeper in the water column.

Given that Atlantic sturgeon have been documented to seek out cooler waters when temperatures rise to 28°C and that prolonged exposure to these temperatures could be stressful, we would expect that Atlantic sturgeon would avoid prolonged exposure to waters with temperatures above 28°C (82.4°F). However, Markin (2017) indicated that during summer months adult Atlantic sturgeon were frequently captured in regions that bioenergetics models predicted nil or negative growth in juveniles due to water quality conditions, suggesting that older Atlantic sturgeon may not be as sensitive to unfavorable environmental parameters as earlier life stages. Markin notes that bioenergetics models can show biases in their parameterization owning to experimental design limits, including size of study organisms, the matter in which fish are experimentally exposed to water quality conditions, and measure responses. Additionally, bioenergetics models account for physiological effects from specific water quality criteria without accounting for behavioral adaptations that sturgeon possess for spawning, migration, or foraging. Rather than responding immediately to stressful temperature conditions, adult sturgeon may be enduring such conditions to accommodate fall spawn behavior (Markin 2017). This suggests that, consistent with the captures by Balazik et al. (2012; up to 30°C) of adults in the James River, that adult Atlantic sturgeon may move through waters above 28°C. Under certain circumstances (low water conditions, high ambient water temperatures, facility operating near capacity), the thermal plume may preclude Atlantic sturgeon from moving upstream past the facility. In these circumstances, we would expect adults to hold downstream and then move upstream when conditions improve (likely at the turn of the tide). Because we do not expect these poor conditions to persist for more than a tidal cycle (i.e., six hours), we do not expect any consequences to adults that may need to temporarily hold below the Jones Neck oxbow. It is also important to note that these conditions are not expected to occur throughout the entirety of the migration period and are expected only in extreme circumstances and would be even less common now given the reduced operations of the plant.

Based on previous work, fall spawning is the dominant spawning behavior in the James River and other Chesapeake Bay tributaries (Balazick *et al.* 2012, Balazick and Musick, 2015). In the James River, adult fish have been routinely captured in temperature above 25°C in the lower portion of the river where Atlantic sturgeon are staging during summer months prior to spawning between August and early-October. Telemetry data show that of 155 males tagged upstream during the fall of 2014, over half returned to the river during May and June 2015 for a downstream staging period (around rkm 40) in brackish water during the summer before moving upstream in August or early September (Balazick and Musick, 2015). Adults may be tolerating super-optimal temperatures and sub-optimal dissolved oxygen levels to time the production of their progeny when environmental parameters are in a suitable range to increase survival and growth of their young (Bonga 1997, Markin 2017). Other fish species (e.g. Pacific salmon and American Shad) are known to also time spawning events so that mismatch between the needs of the progeny does not occur, therefore putting adults in less favorable conditions (i.e. higher energetic costs, higher predation risks, thermal stress)(Crozier et al. 2008, Legget and Carscadden 1978, Markin 2017).

During gill netting studies conducted from August – October of 2011, spawning condition adults were collected in the vicinity of CPS in water temperatures within the range of 20-25°C (Balazick et al. 2012b). Gill netting and telemetry studies conducted from 2012-2014 indicate that spawning condition adults caught and tagged in the vicinity of CPS were detected up to the fall line at rkm 155 (Balazick and Musick 2015). Despite the presence of a thermal plume which can create super-optimal water temperatures during August on low tides, sturgeon continue to move pass CPS and spawn successfully, indicating that there are at least some days and times of the day during the spawning period that sturgeon can pass through. The available data do not provide evidence for a true zone of passage at all times when conditions constitute stressful water temperatures for sturgeon (e.g. hot summer days on low tide under full operating load at CPS). However, based on the empirical evidence of Atlantic sturgeon presence in the vicinity of CPS at rkm 132, upriver detections, and documented annual returns, it is extremely unlikely that thermal plume will preclude any Atlantic sturgeon from completing up and downriver migrations or that the fitness of any pre- or post-spawn individuals will be affected by thermal influences. Therefore, while we expect that the thermal discharge may result in some exposure of adults to temperatures above 28°C, we also note that the area influenced by these temperatures are small and exposure is expected to be brief and limited only to the period of time it takes a sturgeon to swim through the mixing zone which is expected to be no more than a few minutes. Based on the best available information, effects to migration are expected to be so small that they can not be meaningfully measured, evaluated, or detected, and are therefore insignificant.

Water temperature and dissolved oxygen levels are related, with warmer water generally holding less dissolved oxygen. As such, we considered the potential for the discharge of heated effluent to affect dissolved oxygen in the action area. Dissolved oxygen in the tidal freshwater James River typically varies between 13 mg/L during winter months to 6 mg/L during the summer, with no values of less than 5 mg/L recorded (Moore et al. 2006). Dissolved oxygen monitoring conducted as part of the CWA 316(a) demonstration study indicated that despite the influence of thermal discharge, dissolved oxygen sags which had been prevalent in the James River no longer exist and that sufficient oxygen levels exist for fish even in the hottest parts of summer (VEPCO 2000). Based on this information, while adult Atlantic sturgeon migrating past the CPS may be exposed to the thermal discharge, effects of this exposure are expected to be so small that they can not be meaningfully measured, evaluated, or detected and are therefore, insignificant.

9.3.3.3 Other Pollutants Discharged to the James River

All discharges associated with CPS operations are regulated according to VPDES Permit Number VA0004146 (see Table below). As noted in the Fact Sheet for that permit, the effluent limitations contained in this permit will maintain the Water Quality Standards of 9VAC25-260 et seq. (Table 10). Discharge limits are in compliance with the CWA for Section 303(d) with respect to Total Maximum Daily Load (TMDL) for the receiving water body and the Main Channel of the James River is a Category 5D water body, meaning the Water Quality Standard is not attained and where TMDLs for a pollutant(s) have been developed. The VPDES permit contains conditions for each discharge that were developed with consideration for the IAP and the resulting transition in wastewater management and discharges that will occur (see *Polluted Effluent*, section 3.4.1.2).

Pollutant	Limitation
Outfall 001 – Condenser Cooling Water from Units 7 and 8	
Total Residual Chlorine	22 µg/L monthly average 32 µg/L daily maximum
Outfall 002 - Condenser Cooling Water from Unit 3*	
Total Residual Chlorine	22 µg/L monthly average 32 µg/L daily maximum
Dissolved Copper	Monitoring only
Outfall 003 - Condenser Cooling Water from Units 4, 5, and 6	
Total Residual Chlorine	11 µg/L monthly average 16 µg/L daily maximum
Outfall 004 – Pre-Drawdown	
Total Suspended Solids	30 mg/L monthly average 88 mg/L daily maximum
Ammonia as N	0.61 mg/L monthly average 0.80 mg/L daily maximum**
Total Organic Carbon	110 mg/L daily maximum
Total Recoverable Thallium	0.47 µg/L monthly average
Total Petroleum Hydrocarbons	Monitoring Only
Total Recoverable Selenium	5.9 µg/L monthly average 7.3 µg/L daily maximum**
Oil and Grease	15 mg/L monthly average 20 mg/L daily maximum
Outfall 005 - Pre-Drawdown	
Total Suspended Solids	30 mg/L monthly average 100 mg/L daily maximum
Oil and Grease	15 mg/L monthly average 20 mg/L daily maximum

Table 10. Observed Pollutants that are addressed in the Water Quality Standards (VDEQ 2016)

Data on toxicity as it relates to Atlantic sturgeon is extremely limited. In the absence of species specific chronic and acute toxicity data, the EPA aquatic life criteria represent the best available scientific information. Absent species specific data, it is reasonable to consider that those criteria are applicable to NMFS listed species as these criteria are derived from data using the most sensitive species and life stages for which information is available. To develop aquatic life criteria, a suite of species is utilized to develop criteria and these species are intended to be representative of the entire ecosystem[6]. These criteria are designed to not only prevent mortality but to prevent all "unacceptable effects," which, as noted above, is defined by EPA to include not only lethal effects but also effects that impair growth, survival, and reproduction.

[6] Information on Aquatic Life Criteria is available in the documents available at: https://www.epa.gov/wqc/aquatic-life-criteria-and-methods-toxics; last accessed September 3, 2020.

For CPS, the relevant water quality criteria are the Virginia water quality criteria, which must be certified by EPA every three years. This certification process is designed to ensure that the water quality standards are consistent with, or more protective than, the EPA national recommended aquatic life criteria. Based on this reasoning outlined above, for the purposes of this consultation, we consider that effects to Atlantic sturgeon from exposure to pollutants that are discharged with no reasonable potential to cause excursions in water quality standards, will have effects on Atlantic sturgeon that are either extremely unlikely to occur or are so small that they can not be meaningfully measured, evaluated, or detected.

9.3.3.4 Effects of Discharges on Atlantic sturgeon prey

Atlantic sturgeon feed primarily on benthic invertebrates; these prey species are found on the bottom. As explained above, the tidal cycle plays an integral role in the presence/absence of the thermal plume, i.e., on an incoming tide the plume is fairly confined to Farrar Gut while on an outgoing tide it may extend downstream of Farrar Gut. Thermal modeling done under full operating load conditions resulted in average modeled increases in temperature for the entire Farrar Gut as 1.1°C (2.0°F) and 0.6°C (1.2°F) in the James River (VEPCO 2000).

Past studies documented similar results and attributed water temperature reductions in the lower portions of Farrar Gut primarily to the mixing of thermal effluent with cooler tidal waters therefore preventing large areas of the mainstem James River from being thermally altered by more than a few degrees (Jensen 1974). The CWA 316(a) demonstration study conducted from 1997 to 1999 characterized the interaction of the thermal discharge from the station's Outfall 003 with spatial and temporal variation of biological resources near CPS. The results of this study indicated that the benthic macroinvertebrate community of the tidal region of the James River adjacent to CPS is dominated by two major groups: the *Oligochaeta* (worms) and *Chrironmidae* (midges). An examination of the benthic data collected throughout the study revealed that the area of thermal impact to the benthic community is limited to the upper sections of the Farrar Gut as evidenced by the results at the sampling station closest to Outfall 003 (i.e. FG2), especially in summer. During other periods of the year, the benthic community at FG2 underwent some measure of improvement. At sampling stations located further downstream in Farrar Gut, the benthic community was similar to that found in the mainstem James River (VEPCO 2000). Considering that Atlantic sturgeon are also likely to be excluded from areas where the thermal plume influences bottom water temperatures and given that those areas are small, foraging sturgeon are not likely to be affected by any limits on the distribution of benthic invertebrates caused by the thermal plume’s limited influence on bottom waters. Thus, based on this analysis, it appears that the prey of Atlantic sturgeon, would be impacted insignificantly, if at all, by the thermal discharge from CPS and therefore any effects to Atlantic sturgeon will be so small that they can not be meaningfully measured, evaluated, or detected and effects will be insignificant.

9.3.4 Vessel Traffic

As discussed in previous sections, CPS generally accepts 4 to 6 barge deliveries of limestone and a similar number of shipments of gypsum every month. The vessels associated with CPS are shallow draft vessels that are slow moving (speeds of 1 to 7 knots). A fully loaded barge would provide a minimum of 14 feet of below keel clearance during upriver transits, and a minimum of

23 feet of below keel clearance on the downriver transits. Vessels will be loaded or unloaded at the CPS off-loading/loading facility by tying up at mooring points that extend riverward and are not expected to set an anchor. Here we consider the potential for sturgeon-vessel as vessels perform docking/undocking maneuvers at the CPS barge slip and while transiting to and from the site.

Sturgeon-vessel interactions (i.e. propeller strikes) reported in Balazik *et al.* 2012c indicates that a large majority of incidents of propeller strikes in the James River appeared to be linked to maneuvering of deep-draft ocean cargo vessels through a 25-rkm (15.5 rm) stretch of the federal navigation channel upstream of rkm 120 (rm 74.5), characterized with a narrow width and channel depth, formed an area of increased injury and mortality risk compared to downstream areas that contained deeper refuge areas. Results of the study suggested that tagged Atlantic sturgeon were rarely located at the depths utilized by tugboats and small recreational craft in the James River between rkm 76 and rkm 131 (Balazick *et al.* 2012c). Tracking efforts to characterize sturgeon movements of Atlantic sturgeon in the James River demonstrated that individual tagged sturgeon remain in the navigation channel or move to the adjacent shoals during the passage of commercial vessels (Reine *et al*. 2014). Similar to Balazik et al. (2012c), Reine et al. (2014) stated the tagged juvenile Atlantic sturgeon spent the majority of time in deeper waters. Because CPS limestone deliveries and gypsum shipments are expected to be limited to shallow draft vessels, and based on studies showing that Atlantic sturgeon utilized depths deeper than those that occur at the CPS barge slip (i.e. the navigation channel), we conclude that interactions between Chesapeake Bay DPS Atlantic sturgeon and vessels associated with CPS operations are extremely unlikely to occur.

9.4 Consideration of the Effects of the Action in the Context of Predicted Climate Change

Above, we provided general information on the anticipated future effects of climate change on Atlantic sturgeon. While we expect that warming and other global scale environmental changes will continue into the foreseeable future, given the short period of time considered in this consultation (five years), we do not expect any changes in the use of the action area by any ESA listed species to be realized during this period. It is possible that the range of sea turtles may shift northward over time as waters continue to warm; however, we do not expect conditions to change in the action area that would result in sea turtles occurring outside of the portion of the action area described herein. This is because the primary factor affecting the distribution of sea turtles in the James River is salinity and we do not expect any changes in the salinity regime in the James River over the next five years to result in a change in distribution of sea turtles. Also, given those same considerations for salinity, we do not expect any changes in the distribution of Atlantic sturgeon in the action area over this time period. Therefore, we are not anticipating any different effects to any NMFS listed species in the action area due to climate change or related environmental conditions over the five-year period considered here.

10.0 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

We expect that activities described in the *Environmental Baseline* will continue to impact Atlantic sturgeon and their critical habitat over the life of the proposed action. During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions reasonably certain to occur in the action area. We are not aware of any non-Federal actions that are likely to occur in the action area over the life of the proposed action that were not considered in the *Environmental Baseline* section of this Opinion.

Actions carried out or regulated by the Commonwealth of Virginia within the action area that may affect Atlantic sturgeon include the authorization of state fisheries and the regulation of point and non-point source pollution through the National Pollutant Discharge Elimination System. As such, sources of effects to Atlantic sturgeon in the action area include incidental capture, injury, and mortality in state-regulated fishing activities, injury or mortality due to private/commercial vessel collisions, and effects to individuals and their habitat from point source and non-point source pollution regulated by Virginia.

Future commercial fishing activities in state waters may affect Atlantic sturgeon in a number of ways-through entanglement/entrainment in gear, etc. However, it is not clear to what extent these future activities would affect Atlantic sturgeon differently than the current state fishery activities described in the Environmental Baseline section. The Atlantic Coastal Cooperative Statistics Program (ACCSP) and the NMFS sea turtle/fishery strategy are expected to provide information on takes of protected species in state fisheries and systematically collect fishing effort data, which will be useful in monitoring impacts of the fisheries. Currently, fisheries for largemouth bass, commercial pound net fisheries, and crab fisheries exist in the James River. NMFS expects these state water fisheries to continue in the future, and as such, the potential for interactions with Atlantic sturgeon will also continue.

The Commonwealth of Virginia has been delegated authority to issue National Pollutant Discharge Elimination System (NPDES) permits by the EPA. These permits authorize the discharge of pollutants in the action area. Permittees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through the State Pollutant Discharge Elimination System (SPDES) permits. However, this Opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the *Status of the Species* and *Environmental Baseline* sections of this Opinion.

Excessive turbidity due to coastal development and/or construction sites could also influence Atlantic sturgeon in the action area. Additional sources of contamination in the action area include atmospheric loading of pollutants, storm water runoff from coastal development, groundwater discharges, and industrial development. Chemical contamination may have an effect on Atlantic sturgeon reproduction and survival. While dependent upon environmental stewardship and clean-up efforts, impacts from marine pollution, excessive turbidity, and chemical contamination on marine resources and the Virginia coastal ecosystem are expected to continue in the future.

We do not have any information to indicate that effects of the activities described here, over the life of the proposed action will have different effects than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change.

11.0 INTEGRATION AND SYNTHESIS OF EFFECTS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 11) to the *Environmental Baseline* (Section 9) and the *Cumulative Effects* (Section 12) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species* (Section 8) while also considering effects in context of climate change. The purpose of this analysis is to determine whether the action, in the context established by the status of the species, environmental baseline, and cumulative effects, is likely to jeopardize the continued existence of the Chesapeake Bay DPS of Atlantic sturgeon.

Below, we summarize the status of the species and consider whether the action will result in reductions in reproduction, numbers or distribution of these species and then consider whether any reductions in reproduction, numbers or distribution resulting from the action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the federal Endangered Species Act. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act."

While genetic and tracking data demonstrate that adult sturgeon from all five DPSs spend time in the James River (Hildebrand and Schroeder 1928, ASSRT 2007, Hager *et al.* 2011, NMFS 2012), we expect the majority of the adults in the action area to originate from the Chesapeake Bay DPS and that all of the adults near CPS will originate from the Chesapeake Bay DPS. The Chesapeake Bay DPS has been listed as endangered. There are four known spawning subpopulations for the Chesapeake Bay DPS, one each for the Pamunkey River and for Marshyhope Creek, and two for the James River. At the time of listing, the James River was the only known spawning river for the Chesapeake Bay DPS and spawning was believed to occur only in the spring, from approximately April –May, based on historical and current evidence (NMFS and USFWS 2007). Subsequently, new information for when and where spawning-condition adults were captured and tracked in the river led to the conclusion that Atlantic sturgeon spawn in the James River in both the spring and fall (Balazik *et al*. 2012b, Balazik and Musick 2015). Per Matt Balazik 2019 (pers. comms.), the updated estimated male population for the fall cohort is approximately 3,707 individuals and the estimated annual female spawning population is 1,250 individuals (Balazik 2019 pers. comms.).

Based on the best available information, the Chesapeake Bay DPS spawns in upstream reaches of the James River during an approximate three-week period typically in September (Balazick 2019 pers. comms.). Once hatched, it is anticipated that it takes approximately three weeks for Atlantic sturgeon larvae to develop into young-of-year fish and move downstream of the CPS facility. Based on this information, it is estimated that Atlantic sturgeon larvae could be present within the water column in the vicinity of CPS for up to six weeks during September and October.

The ITP proposes to authorize the lethal take by entrainment of a total of 54,747 larval Atlantic sturgeon; this consists of one Atlantic sturgeon larvae killed during 316(b) entrainment sampling and up to 54,746 larvae killed due to entrainment during CPS operations at a rate of an annual average of 10,949 (range 1,820 – 33,789, total 54,747) larval sturgeon from the Chesapeake Bay DPS per year for five years. While we processed the application using 10,949 as the average estimated annual take, we also considered the effects of take by entrainment at the lower and upper ends of the range for larval takes (i.e. 95% confidence interval). We concluded that take could not exceed 33,789 larvae for more than one of the five years over the course of the 5-year permit period without surpassing the amount of authorized take permitted. As described in the *Effects of the Action* section of this Opinion, no impingement of Atlantic sturgeon is expected and all other effects of the continued operation of the CPS are extremely unlikely to occur or are insignificant.

Here, we consider the effect of the loss of 54,747 Atlantic sturgeon larvae over a five-year period on the James River population of Atlantic sturgeon and then consider those effects in the context of the Chesapeake Bay DPS as a whole. The mortality of these larvae, at a rate of an annual average of 10,949 larval sturgeon from the Chesapeake Bay DPS per year for five years is not expected to have a measurable effect on the numbers, reproduction, or distribution of the James River population for several reasons. First, the loss of these larvae represents an extremely small percentage of the total larvae expected to be produced in any one year of the five year permit and an even smaller percentage of the total larvae expected to be produced over the life of the permit. A single female Atlantic sturgeon produces from 400,000 to 4 million eggs when it spawns (Boreman 1997, Van Eenennaam *et al*. 1996, Van Eenennaam and Doroshov 1998, Gross *et al*. 2002). Balazik (2012) reported fecundities as high as 8 million eggs per spawning female per year. The estimate of fall spawning females in the James River by Balazik (2019) mentioned above, when extrapolated, translates to approximately 41,294,134 (range 41,264,367 to 43,074,900) larval sturgeon in the James River during the fall spawning season. Therefore, even considering the highest annual amount of take that would be authorized (33,789), only a very small percentage (0.08 percent annually) of the population of larval Atlantic sturgeon in the James River in a given fall spawning season could be expected to experience mortality due to interaction with CPS CWISs. It is important to note that the loss of larvae is not comparable to the potential population impacts of the loss of the same number of older life stages. This is because mortality of sturgeon during larval life stages is naturally high due to small body size, limited swimming ability, predation, and sensitivity to variations in their surrounding environment (reviewed in Hardy and Litvak 2004). Based on this analysis, the loss of larvae due to entrainment at CPS over the five-year life of the permit is not expected to have a detectable effect on the strength of any year class or the number of juveniles, subadults, or adults resulting from that year class for the James River population.

Effects on reproduction are limited to the hypothetical future loss of reproductive capacity from individual larvae that are killed. Given that the loss of larvae will not have a detectable effect on the strength of any year class or the number of juveniles, subadults, or adults resulting from that year class for the James River population, any effects on future reproductive success of the James River population is expected to be undetectable. The proposed action is not expected to have any effects on the distribution of Atlantic sturgeon in the James River.

The James River population is one portion of the Chesapeake Bay DPS. Based on the information provided above, the death of an average of 10,949 Chesapeake Bay DPS Atlantic sturgeon larvae annually over a 5-year period (i.e., 54,747 larvae total over the five year period) plus 1 larvae resulting from the continued operation of the CPS and completion of CWA 316(b) studies will not appreciably reduce the likelihood of survival of the Chesapeake Bay DPS (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). Implementation of the proposed Conservation Plan is expected to minimize the take of adult Chesapeake Bay DPS Atlantic sturgeon at CPS to zero, and will result in the collection of information that could be used to inform Dominion of other measures for minimizing take. The action will not affect Chesapeake Bay DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity; and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) take of an estimated 10,949 larval Atlantic sturgeon annually from the James River population, over a 5-year period, represents an extremely small percentage of this population and an even smaller percentage of the DPS as a whole; (2) the death of up to 54,747 larval Chesapeake Bay DPS Atlantic sturgeon (i.e., 54,746 from operation of CPS and 1 from completion of the 316(b)studies) as a worst case scenario will not change the status or trends of the James River population or the DPS as a whole; (3) the loss of these larval Chesapeake Bay DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these larval Chesapeake Bay DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the James River population or the DPS as a whole; (5) the action will have no effect on the ability of Chesapeake Bay DPS Atlantic sturgeon to reach spawning areas; and (6) the action will benefit the Chesapeake Bay DPS of Atlantic sturgeon by eliminating impingement of adults as a result of changes to CPS intake guards, and thus reducing impingement to zero.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or, the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the Chesapeake Bay DPS will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed action will affect the likelihood that the Chesapeake Bay DPS can rebuild to a point where listing is no longer appropriate.

In 2018, NMFS published a Recovery Outline to serve as an initial recovery planning document that outlines the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted (NMFS 2018). In this, the recovery vision is stated, "Subpopulations of all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and that increased recruitment must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future." The Outline also includes steps that are expected to serve as an initial recovery action plan. These include: protecting extant subpopulations and the species' habitat through reduction of threats; gathering information through research and monitoring on current distribution and abundance; and addressing vessel strikes in rivers, the effects of climate change and bycatch.

We know that in general, to recover, a species must have a sustained positive trend over time and an increase in population. To allow those things to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (i.e., spawning, foraging, resting) and have access to enough food. Here, we consider whether this proposed action will affect the population size and/or trend in a way that would affect the likelihood of recovery.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of Chesapeake Bay DPS Atlantic sturgeon and since it will not affect the overall distribution of Chesapeake Bay Atlantic sturgeon. Any effects to habitat will be insignificant and discountable and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. The proposed action will result in a small amount of mortality (up to 54,747 larvae total over the 5-year permit duration) and a subsequent effect on potential future abundance and reproductive output that is expected to be undetectable at the population level. For these reasons, it is not expected to affect the persistence of the James River population or the Chesapeake Bay DPS of Atlantic sturgeon. This action will not change the status or trend of the James River population or the Chesapeake Bay DPS of Atlantic sturgeon. The very small reduction in numbers and potential future reproduction resulting from the proposed action will not reduce the likelihood of improvement in the status of the Chesapeake Bay DPS of Atlantic sturgeon. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the Chesapeake Bay DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual Chesapeake Bay DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed action, resulting in the mortality of an estimated 10,949 Chesapeake Bay DPS Atlantic sturgeon larvae annually (up to 54,747 total over the 5-year permit duration), is not likely to appreciably reduce the survival and recovery of this DPS.

12.0 CONCLUSION

After reviewing the current status of endangered Chesapeake Bay DPS Atlantic sturgeon and designated critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our Opinion that the issuance of this incidental take permit to Virginia Electric and Power Company (Dominion) is not likely to jeopardize the continued existence of the Chesapeake Bay DPS of Atlantic sturgeon. It is also our biological opinion that the issuance of this incidental take permit to Dominion is not likely to adversely affect the James River critical habitat unit for the Chesapeake Bay DPS, shortnose sturgeon, the Gulf of Maine, New York Bight, Carolina, and South Atlantic DPSs of Atlantic sturgeon, North Atlantic DPS green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtles.

13.0 INCIDENTAL TAKE STATEMENT

Dominion's Conservation Plan and its associated documents clearly identify anticipated impacts to the Chesapeake Bay DPS of Atlantic sturgeon likely to result from the proposed taking and the measures that are necessary and appropriate to minimize those impacts. All conservation measures described in the proposed Conservation Plan, together with the terms and conditions of any section 10(a)(1)(B) permit or permits issued with respect to the proposed Conservation Plan, are incorporated herein by reference as reasonable and prudent measures and terms and conditions within this incidental take statement as stated in 50 CFR 402.14(i). Such terms and conditions are non-discretionary. The amount or extent of incidental take anticipated under Dominion's proposed Conservation Plan, associated reporting requirements, and provisions for disposition of dead or injured animals are as described in the Conservation Plan and its accompanying section 10(a)(1)B) permit(s).

13.1 Amount or Extent of Take

The proposed action is likely to result in the entrainment and mortality of an average of 10,949 Atlantic sturgeon larvae annually over the next five years for a total estimated take of 54,745

Atlantic sturgeon larvae due to normal operation of CPS over the 5-year permit duration. That take cannot exceed 33,789 larvae for more than one of the five years over the course of the 5-year permit period without surpassing the amount of authorized take permitted. In addition, the CWA 316(b) studies at CPS, pursuant to CWA 316(b) requirements, are expected to result in the entrainment and mortality of one Atlantic sturgeon larvae.

We believe this level of incidental take is a reasonable estimate of incidental take that will occur given the fall spawning period and location for Chesapeake Bay DPS Atlantic sturgeon, and anticipated CPS operation in the action area.

13.2 Reasonable and Prudent Measures and Terms and Conditions

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and terms and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures and terms and conditions are specified as required by 50 CFR 402.12 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and minimize the impact of that take on ESA-listed species. The reasonable and prudent measures are nondiscretionary, and must be undertaken by NMFS so that they become binding conditions for the exemption in section 7(o)(2) to apply.

The proposed action contains all measures necessary and appropriate to minimize the extent of incidental take of Chesapeake Bay DPS Atlantic. Monitoring will be conducted as stated in section 6.1.3 of the Conservation Plan. We have determined that additional measures are appropriate to document incidental take that does occur. Please note that these reasonable and prudent measures and terms and conditions are in addition to the measures that Dominion has committed to and the additional measures that NMFS has indicated they will require as conditions of the ITP as all these are considered part of the proposed action (see section 3 above). We consider that a failure to implement the measures identified as part of the proposed action would be a change in the action that may necessitate reinitiation of consultation.

We have determined the following reasonable and prudent measures are necessary and appropriate to document the impacts of incidental take of threatened and endangered species during the proposed action:

1. NMFS must ensure that over the five-year life of the permit, Dominion submits an annual estimate of the total amount of take of Atlantic sturgeon at the facility. This will allow for tracking of incidental take for the purposes of determining if the amount of take exempted by the ITS has been exceeded.

To be exempt from the prohibitions of section 9 of the ESA, NMFS must comply with the following terms and conditions, which implement the reasonable and prudent measure above. These terms and conditions are non-discretionary

1. The following terms and conditions implement reasonable and prudent measure 1:
    a. Dominion must prepare an annual reporting plan that details how observed take of Atlantic sturgeon will be extrapolated to generate an accurate and reliable estimate of total take at the facility. This report is due to NMFS within 90 days of issuance of the ITP.
    b. Dominion must submit reports of any observed take of Atlantic sturgeon to NMFS (incidental.take@noaa.gov) within 7 days. These reports must include the information consistent with the data fields on the reporting form included in Appendix A.
    c. Each year, Dominion must prepare an annual report detailing all observed takes of Atlantic sturgeon at CPS. This report must include a reliable and reasonable estimate of the total amount of take derived from the observations using the agreed to methodology outlined in the annual reporting plan detailed above. Draft annual reports are to be submitted to NMFS by February 15 of each year (e.g., the 2020 report is due on February 15, 2021). NMFS will provide any comments or suggestions back to Dominion by April 1 and a final report is due to NMFS by May 15. The review of this annual report provides an opportunity to monitor the ongoing amount of take at CPS and detect any trends that may indicate a potential exceedance of the ITS before such an event occurs.

14.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. There are no conservation recommendations associated with this proposed action.

15.0 REINITIATION NOTICE

This concludes formal consultation on our proposed issuance of an incidental take permit to Virginia Electric and Power Company (Dominion) pursuant to the provisions of section 10(a)(1)(B) of the Endangered Species Act. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

16.0 LITERATURE CITED

Allen PJ, Nicholl M, Cole S, Vlazny A, Cech JJ Jr. 2006. Growth of larval to juvenile green sturgeon in elevated temperature regimes. Trans Am Fish Soc 135:89–96

Altenritter, M.E., G.B. Zydlewski, M.T. Kinnison, J.D. Zydlewski, and G. S. Wippelhauser. 2017. Understanding the basis of shortnose sturgeon (*Acipenser brevirostrum*) partial migration in the Gulf of Maine. Can. J. Fish. Aquat. Sci. 75(3):464-473.

ASMFC (Atlantic States Marine Fisheries Commission). 1998a. Atlantic Sturgeon Stock Assessment Peer Review Report. March 1998. 139 pp.

ASMFC. 2007. Special Report to the Atlantic Sturgeon Management Board: Estimation of Atlantic sturgeon bycatch in coastal Atlantic commercial fisheries of New England and the Mid-Atlantic. August 2007. 95 pp.

ASMFC. 2012. Habitat Addendum IV to Amendment 1 to the Interstate Fishery Management Plan for Atlantic Sturgeon.

Atlantic Sturgeon Status Review Team (ASSRT). 2007. Status Review of Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.

Austin, G. 2012. Essential spawning habitat for Atlantic sturgeon in the James River, Virginia. Master of Science Thesis. Virginia Commonwealth University, Richmond, Virginia.

Balazik, M.T. 2017. First verified occurrence of the shortnose sturgeon (*Acipenser brevirostrum*) in the James River, Virginia. Fish. Bull. 115:196–200.

Balazik, M.T., S.P. McIninch, G.C. Garman, and R.J. Latour. 2012a. Age and growth of Atlantic sturgeon in the James River, Virginia, 1997–2011. Transactions of the American Fisheries Society. 141(4):1074-1080.

Balazik, M.T., G.C. Garman, J.P. VanEenennaam, J. Mohler, and C. Woods III. 2012b. Empirical evidence of fall spawning by Atlantic sturgeon in the James River, Virginia. Transactions of the American Fisheries Society 141(6):1465-1471.

Balazik, M.T., K.J. Reine, A.J. Spells, C.A. Fredrickson, M.L. Fine, G.C. Garman, and S.P. McIninch. 2012c. The potential for vessel interactions with adult Atlantic sturgeon in the James River, Virginia, North American Journal of Fisheries Management. 32(6):1062-1069.

Balazik, M.T., J.A. Musick. 2015. Dual annual spawning races in Atlantic sturgeon. PLoS ONE 10(5): e0128234.

Balazik MT, D.J. Farrae, T.L. Darden, G.C. Garman. 2017. Genetic differentiation of spring-spawning and fall-spawning male Atlantic sturgeon in the James River, Virginia. PLoS ONE 12(7): e0179661.

Balazik M, M. Barber, S. Altman, K. Reine, A. Katzenmeyer, A. Bunch, et al. (2020) Dredging activity and associated sound have negligible effects on adult Atlantic sturgeon migration to spawning habitat in a large coastal river. PLoS ONE 15(3): e0230029. https://doi.org/10.1371/journal.pone.0230029

Bath, D.W, J.M. O'Connor, J.B. Alber, and L.G. Arvidson. 1981. Development and identification of larval Atlantic sturgeon (*Acipenser oxyrhynchus*) and shortnose sturgeon (*A. brevirostrum*) from the Hudson River Estuary, New York. Copeia, 3:711-717.

Bay Journal. 2016. Biologists alarmed over lack of young Atlantic sturgeon in surveys. Article by Karl Blankenship. August 15, 2016.

Beamesderfer, R.C.P. and R.A. Farr. 1997. Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48:407-417.

Bonga, S.E.W. 1997. The stress response of fish. Physiological Reviews 77(3): 591- 625.

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. Environmental Biology of Fishes 48: 399-405.

Breece M.W., M.J. Oliver, M.A. Cimino, D.A. Fox. 2013. Shifeeting distributions of adult Atlantic sturgeon amidst post-industrialization and future impacts in the Delaware River: a maximum entropy approach. PLoS ONE 8(11): e81321. doi:10.1371/journal.pone.0081321.

Brown, H.W. 1974. Handbook of the effects of temperature of some North American fishes. American Electric Power Service Corporation, Canton, Ohio.

Bushnoe, T.M., J.A. Musick, D.S. Ha. 2005. Essential spawning and nursery habitat of Atlantic sturgeon (*Acipenser oxyrinchus*) in Virginia. Provided by Jack Musick, Virginia Institute of Marine Science, Gloucester Point, Virginia.

Calvo, L., H.M. Brundage, III, D. Haidvogel, D. Kreeger, R. Thomas, J.C. O'Herron, II, and E.N. Powell. 2010. Effects of flow dynamics, salinity, and water quality on Atlantic sturgeon, the shortnose sturgeon, and the Eastern oyster in the oligohaline zone of the Delaware Estuary. Final Report for Project No. 151265. Project Year 2008-2009. Submitted to the U.S. Army Corps of Engineers, Philadelphia District. 106 pp.

CBP (Chesapeake Bay Program). 2002. Chemical and Toxicological Characterization of Tidal Freshwater Areas in the James River, Virginia from Jamestown Island to Jordan Point. Prepared by M.H. Roberts, Jr., M.A. Vogelbein, M.A. Richards, L. Seivard, and Contractor # WM C395. CBP/TRS 264/02; EPA 903-R-02-006.

Chesapeake Bay Magazine. 2018. Sturgeon Making a Comeback in the James River. Article by Laura Adams Boycourt. October 30, 2018.

Chytalo, K. 1996. Summary of Long Island Sound dredging windows strategy workshop. In Management of Atlantic Coastal Marine Fish Habitat: Proceedings of a Workshop for Habitat Managers. ASMFC Habitat Management Series #2.

Crozier, L.G., A.P. Hendry, P.W. Lawson, T.P. Quinn, N.J. Mantua, J. Battin, R.G. Shaw, and R.B. Huey. 2008. Evolutionary Applications 252-270.

Damon-Randall, K., R. Bohl, S. Bolden, D. Fox, C, Hager, B. Hickson, E. Hilton, J. Mohler, E. Robbins, T. Savoy, and A. Spells. 2010. Atlantic sturgeon research techniques. NOAA Tech. Memo. NMFS-NE -215. 74pp.

Dionne, P.E., G.B. Zydlewski, M.T. Kinnison, J. Zydlewski, and G.S. Wippelhauser. 2013. Reconsidering residency: characterization and conservation implications of complex migratory patterns of shortnose sturgeon (*Acipenser brevirostrum*). Can. J. Fish. Aquat. Sci. 70:119–127.

Dominion Resources Services, Inc. (Dominion). 2003. Intake Maintenance Dredging - Joint Permit Application, Chesterfield Power Station, Chesterfield, Virginia.

Dominion 2016a. Entrainment Characterization Study Plan. Prepared by HDR Engineering, Inc.

Dominion 2016b. Impingement Characterization Study Plan. Prepared by HDR Engineering Inc.

Dominion 2016c. Dominion 316(b) Implementation, Chesterfield Power Station Area of Influence. Prepared by HDR Engineering, Inc.

Dominion. 2017. Incidental Take Permit (ITP) Application and associated Conservation Plan. Submitted to NOAA Fisheries, Greater Atlantic Region Fisheries Office, April 7, 2017.

Dominion. 2019. Incidental Take Permit (ITP) Application; Responses to February 13, 2019 Comments and Revised Incidental Take Estimates. Submitted to NOAA Fisheries, Greater Atlantic Region Fisheries Office, October 16, 2019.

Dominion. 2020. Dominion Energy Response to Southern Environmental Law Center Comments on NMFS's Proposed Issuance of a 5-Year Incidental Take Permit to Dominion Energy for the Take of Atlantic Sturgeon, Chesapeake Bay Distinct Population Segment, at the Chesterfield Power Station in Chesterfield. Submitted to NOAA Fisheries, Greater Atlantic Region Fisheries Office, August 3, 2020.

Dunton, K.J., A. Jordaan, D.O. Conover, K.A. McKown, L.A. Bonacci, and M.G. Frisk. 2015. Marine distribution and habitat use of Atlantic sturgeon in New York lead to fisheries interactions and bycatch. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 7(1):18-32.

Dunton, K.J., A. Jordaan, K.A. McKown, D.O. Conover, and M.J. Frisk. 2010. Abundance and distribution of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) within the Northwest Atlantic Ocean, determined from five fishery-independent surveys. Fishery Bulletin 108:450-465.

EA Engineering, Science, and Technology (EA) 2007. Impingement Mortality and Entrainment Characterization Report, Chesterfield Power Station, June 2005 – 2006. EA Engineering, Science, and Technology, Inc., Sparks, Maryland.

EPA (Environmental Protection Agency). 2008. National Coastal Condition Report III. EPA/842-R-08-002. 329 pp.

EPA. n.d. Chapter 11 for the Proposed Section 316(b) New Facility Rule. Accessible at https://www3.epa.gov/npdes/pubs/chapter11.pdf

Erickson, D.L., A. Kahnle, M.J. Millard, E.A. Mora, M. Bryja, A. Higgs, J. Mohler, M. DuFour, G. Kenney, J. Sweka, and E.K. Pikitch. 2011. Use of pop-up satellite archival tags to identify oceanic-migratory patterns for adult Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus* Mitchell, 1815. J. Appl. Ichthyology 27:356–365.

Greene CH, Pershing AJ, Cronin TM and Ceci N. 2008. Arctic climate change and its impacts on the ecology of the North Atlantic. Ecology 89:S24-S38.

Greenlee, B., D.H. Secor, G.C. Garman, M. Balazak, E.J. Hilton, and M.T. Fisher. 2017. Assessment of Critical Habitats for Recovering the Chesapeake Bay Atlantic Sturgeon Distinct Population Segment. Virginia Institute of Marine Science, College of William and Mary. http://dx.doi.org/doi:10.21220/m2-3gvk-6j03

Gross, M.R., J. Repka, C.T. Robertson, D.H. Secor, and W. Van Winkle. 2002. Sturgeon conservation insights from elasticity analysis. American Fisheries Society Symposium 28:13-30.

Hager, C. 2011. Atlantic Sturgeon Review: Gather data on reproducing subpopulation on Atlantic Sturgeon in the James River. Final Report - 09/15/2010 to 9/15/2011. NOAA/NMFS contract EA133F10CN0317 to the James River Association. 21 pp.

Hager, C., J. Kahn, C. Watterson, J. Russo, and K. Hartman. 2014. Evidence of Atlantic sturgeon spawning in the York River System, Transactions of the American Fisheries Society, 143:5, 1217-1219.

Hale, E.A., Ian A. Park, Matthew T. Fisher, Richard A. Wong, Michael J. Stangl, and John H. Clark. 2016. Abundance estimate for and habitat use by early juvenile Atlantic sturgeon within the Delaware River Estuary. Transactions of the American Fisheries Society, 145:6, 1193-1201, DOI: 10.1080/00028487.2016.1214177.

Haley, N.J. 1999. Habitat characteristics and resource use patterns of sympatric sturgeons in the Hudson River Estuary. M.Sc. Thesis. University of Massachusetts, Amherst, MA 124 p.

Hardy, R. S., and M. K. Litvak. 2004. Effects of temperature on the early development, growth, and survival of shortnose sturgeon, *Acipenser brevirostrum*, and Atlantic sturgeon, *Acipenser oxyrhynchus*, yolk-sac larvae. Environmental Biology of Fishes 70:145-154.

Hatin, D.R., S. Lachance, and D. Fournier. 2007. Effect of dredged sediment deposition on use by Atlantic sturgeon (*Acipenser oxyrinchus*) and Lake sturgeon (*Acipenser fulvescens*) at an open-water disposal site in the St. Lawrence Estuarine Transition Zone. American Fisheries Society Symposium 53:235-255.

Hazel, J., I. R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle Chelonia mydas. Endangered Species Research 3(2):105-113.

Hildebrand, S.F. and W.C. Schroeder. 1928. Fisheries of Chesapeake Bay. Department of Commerce, Bulletin of the United States Bureau of Fisheries, Volume XLIII.

Hill, J. 1996. Environmental considerations in licensing hydropower projects: policies and practices at the Federal Energy Regulatory Commission. American Fisheries Society Symposium 16: 190-199.

Hulme, P.E. 2005. Adapting to climate change: is there scope for ecological management in the face of global threat? Journal of Applied Ecology 43: 617-627.IPCC (Intergovernmental Panel on Climate Change) 2007. Fourth Assessment Report. Valencia, Spain.

HydroQual. 2003. Thermal Modeling of Chesterfield Power Station on the James River and Farrar Gut, Virginia. Prepared for Dominion Generation, Richmond, Virginia.

Intergovernmental Panel on Climate Change (IPCC). 2007a. Climate Change 2007 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. IPCC, Geneva.

Intergovernmental Panel on Climate Change (IPCC). 2007b. Climate Change 2007 - The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. IPCC, Geneva.

IPCC (Intergovernmental Panel on Climate Change). 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

IPCC (Intergovernmental Panel on Climate Change). 2007. Summary for Policymakers. In*:*

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (editors). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA.

Jenkins, W.E., T.I.J. Smith, L.D. Heyward, and D.M. Knott. 1993. Tolerance of shortnose sturgeon, Acipenser brevirostrum, juveniles to different salinity and dissolved oxygen concentrations. Proceedings of the Southeast Association of Fish and Wildlife Agencies, Atlanta, Georgia.

Kahn, J. and M. Mohead. 2010. A protocol for use of Shortnose, Atlantic, Gulf, and Green sturgeons. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-OPR-45. 62 pp.

Kahn, J.E., C. Hager, J. C. Watterson, J. Russo, K. Moore & K. Hartman. 2014. Atlantic sturgeon annual spawning run estimate in the Pamunkey River, Virginia, Transactions of the American Fisheries Society, 143:6, 1508-1514, DOI:10.1080/00028487.2014.945661

Laney, R.W., J.E. Hightower, B.R. Versak, M.F. Mangold, W.W. Cole Jr., and S.E. Winslow. 2007. Distribution, habitat use, and size of Atlantic sturgeon captured during cooperative winter tagging cruises, 1988–2006. Pages 167-182. In: J. Munro, D. Hatin, J. E. Hightower, K. McKown, K. J. Sulak, A. W. Kahnle, and F. Caron, (editors), Anadromous sturgeons: habitats, threats, and management. Am. Fish. Soc. Symp. 56, Bethesda, MD.

Langford, T.E.L. 1990. Ecological effects of thermal discharges. Elsevier Applied Sciece Publishers, London.

Leggett, W.C. and J.E. Carscadden. 1978. Latitudinal variation in reproductive characteristics of American shad (*Alosa sapidissima*): evidence for population specific life history strategies in fish. Journal of the Fisheries Research Board of Canada 35: 1469-1478.

Linden, D. 2018. Comment on Dominion Energy application for ESA permit for incidental take of Chesapeake Bay distinct population of Atlantic sturgeon. Submitted to NOAA Fisheries, Greater Atlantic Region Fisheries Office, December 10, 2018.

Markin, E.L. 2017. Atlantic Sturgeon Acipenser Oxyrinchus Growth Responses to Dual Seasonal Spawning, Latitudinal Thermal Regimes, and Chesapeake Bay Environmental Stressors. Dissertation. University of Maryland Center for Environmental Science.

Mayfield R.B. , J.J. Cech Jr. 2004. Temperature effects on green sturgeon bioenergetics. Trans AmFish Soc 133:961–970

Mayhew, D.A., Jensen, L.D., Hanson, D.F. and Muessig, P.H., 2000. A comparative review of entrainment survival studies at power plants in estuarine environments. Environmental Science & Policy, 3, pp.295-301.

McCord, J.W., M.R. Collins, W.C. Post, and T.J. Smith. 2007. Attempts to develop an index of abundance for age-1 Atlantic sturgeon in South Carolina, USA. American Fisheries Society Symposium 56:397-403.

McQuinn, I.H. and P. Nellis, 2007. An acoustic-trawl survey of middle St. Lawrence estuary demersal fisheries to investigate the effects of dredged sediment disposal on Atlantic and lake sturgeon distribution. American Fisheries Society Symposium 56:257-271.

Moore, K., B. Neikirk, and B.A. Anderson. 2006. Water quality conditions and restoration of submerged aquatic vegetation (SAV) in the tidal freshwater James River 2005. Retrieved October 21, 2016, from http://www.vims.edu/GreyLit/VIMS/sramsoe392.pdf.

Moser, M.L., M. Bain, M.R. Collins, N. Haley, B. Kynard, J.C. O'Herron II, G. Rogers, and T.S. Squiers. 2000. A protocol for use of shortnose and Atlantic sturgeon. NOAA Technical Memorandum NOAA Fisheries Service-OPR-18.

Mulholland, M.R., R.E. Morse, G. Boneillo, P.W. Bernhardt, K.C. Filippino, L.A. Procise, J. Blanco-Garcia, H.G. Marshall, T.A. Egerton, W.S. Hunley, K.A. Moore, D.L. Berry, C.J. Gobler. 2009. Understanding causes and impacts of the dinoflagellate, Cochlodinium polykrikoides, blooms in the Chesapeake Bay. Estuaries and Coasts 32, 734–747.

Murdoch, P.S., J.S. Baron, and T.L. Miller. 2000. Potential effects of climate change on surface water quality in North America. JAWRA Journal of the American Water Resources Association, 36: 347–366.

Murray, T.J. 2016. Testing raised food Lines in Virginia's striped bass fishery: A gear based method of reducing sturgeon interactions in anchored gillnets. VIMS marine resource report ; no. 2016-06. Virginia Institute of Marine Science, College of William and Mary. http://doi.org/10.21220/V5FW24.

Musick, J. A. 2005. Essential Fish Habitat of Atlantic Sturgeon Acipenser oxyrinchus in the Southern Chesapeake Bay. VIMS Special Scientific Report No. 145. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.25773/23s5-8f74

Najjar, R. G., C.R. Pyke, M.B. Adams, D. Breitburg, C. Hershner, M. Kemp, ... & K. Sellner. 2010. Potential climate-change impacts on the Chesapeake Bay. Estuarine, Coastal and Shelf Science, 86(1), 1-20.

NAST (National Assessment Synthesis Team). 2000. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. Washington, D.C.: U.S. Global Change Research Program. http://www.usgcrp.gov/usgcrp/Library/nationalassessment/1IntroA.pdf

Nellis, P., J. Munro, D. Hatin, G. Desrosiers, R.D. Simons, and F. Guilbardi. 2007. Macrobenthos assemblages in the St. Lawrence Estuarine Transition Zone and their potential as food for Atlantic sturgeon and Lake sturgeon. American Fisheries Society Symposium 56:105-128.

Niklitschek, J. E. 2001. Bioenergetics modeling and assessment of suitable habitat for juvenile Atlantic and shortnose sturgeons (Acipenser oxyrinchus and A. brevirostrum) in the Chesapeake Bay. Dissertation. University of Maryland at College Park, College Park.

Niklitschek E.J., and D.H. Secor. 2005. Modeling spatial and temporal variation of suitable nursery habitats for Atlantic sturgeon in the Chesapeake Bay. Estuarine, Coastal and Shelf Science 64:135-148.

Niklitschek, E. J. and D. H. Secor. 2010. Experimental and field evidence of behavioural habitat selection by juvenile Atlantic Acipenser oxyrinchus oxyrinchus and shortnose Acipenser brevirostrum sturgeons. J. of Fish. Biol. 77: 1293-1308.

NMFS (National Marine Fisheries Service). 2012a. Endangered and Threatened Wildlife and Plants; Threatened and endangered status for distinct population segments of Atlantic sturgeon in the Northeast Region. 77 FR 5880, February 6, 2012.

NMFS. 2012a. Endangered Species Act Section 7 Consultation Biological Opinion. James River Federal Navigation Project: Tribell Shoal Channel to Richmond Harbor in Surry, James City, Prince George, Charles City, Henrico, and Chesterfield Counties and the Cities of Richmond and Hopewell, Virginia. NER-2012-01183.

NMFS. 2012b. Endangered and Threatened Wildlife and Plants; Final listing determinations for two distinct population segments of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the Southeast. 77 FR 5914, February 6, 2012.

NMFS. 2013a. Endangered Species Act Section 7 Consultation Biological Opinion. Continued operations of the Indian Point Nuclear Generating Station, Units 2 and 3, pursuant to existing and proposed renewed operating licenses. Pages 163 *in* N. N. R. Office, editor.

NMFS. 2013b. Endangered Species Act Section 7 Consultation on the Biological Opinion, Issuance of Funds to 11 Northeast States and the District of Columbia through the Wildlife and Sport Fish Restoration Program. NER-2012-3996.

NMFS. 2017 Designation of Critical Habitat for the Gulf of Maine, New York Bight, and Chesapeake Bay Distinct Population Segments of Atlantic Sturgeon: ESA Section 4 (b)(2) Impact Analysis and Biological Source Document with the Economic Analysis and Final Regulatory Flexibility Analysis Finalized June 3, 2017.

NMFS. 2018. Recovery Outline for the Atlantic Sturgeon Distinct Population Segments. Available online at https://www.fisheries.noaa.gov/resource/document/recovery-outline-atlantic-sturgeon-distinct-population-segments.

NMFS Northeast Fisheries Science Center (NEFSC). 2011. Summary of Discard Estimates for Atlantic Sturgeon. Prepared by T. Miller and G. Shepard, Population Dynamics Branch. August 19, 2011.

NMFS NEFSC 2012. The Cost-effectiveness of Gear Research Relative to a Closure: Pound Nets and Sea Turtles as an Example. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-01; 25 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

NMFS and USFWS. 2007. Status review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). National Marine Fisheries Service. February 23, 2007. 188 pp.

NRC. 1990. Decline of the sea turtles: causes and prevention. National Academy Press, Washington, D. C.

O'Leary, S.J., K.J. Dunton, T.L. King. M.G. Frisk, and D.D. Chapman. 2014. Genetic diversity and effective size of Atlantic sturgeon, *Acipenser oxyrhinchus oxyrhinchus*, river spawning populations estimated from the microsatellite genotypes of marine-captured juveniles. Conservation Genetics DOI 10.1007/s10592-014-0609-9.

Oakley, N. C. 2003. Status of shortnose sturgeon, Acipenser brevirostrum, in the Neuse River, North Carolina. M. Sc. Thesis. Department of Fisheries and Wildlife Science, North Carolina State University, Raleigh, NC. 100pp.

Oliver, M.J., M.W. Breece , D.A. Fox , D.E. Haulsee , J.T. Kohut , J. Manderson, and T. Savoy. 2013. Shrinking the Haystack: Using an AUV in an Integrated Ocean Observatory to Map Atlantic Sturgeon in the Coastal Ocean, Fisheries 38(5):210-216, DOI: 10.1080/03632415.2013.782861.

Palmer M.A., C.A. Reidy, C. Nilsson, M. Florke, J. Alcamo, P.S. Lake, and N. Bond. 2008. Climate change and the world's river basins: anticipating management options. Frontiers in Ecology and the Environment 6:81-89.

Pyke, C.R., R.G. Najjar. M.B. Adams, D. Breitburg, M. Kemp, C. Hershner, R. Howarth, M. Mulholland, M. Paolisso, D. Secor, K. Sellner, D. Wardrop, and R. Wood. 2008. Climate change and the Chesapeake Bay: State-of-the-science review and recommendation. Report from the Chesapeake Bay Program Science and Technology Advisory Committee (STAC), Annapolis. 59 pp.

Pyzik, L., J. Caddick, and P. Marx. 2004. Chesapeake Bay: introduction to an ecosystem. Chesapeake Bay Program, EPA Publication 903-R-04-003. Annapolis, Maryland.

Reine, K., D. Clarke, M. Balzaik, S. O'Haire, C. Dickerson, C. Frederickson, G. Garman, C. Hager, A. Spells, and C. Turner. 2014. Assessing Impacts of Navigation Dredging on Atlantic

Sturgeon (*Acipenser oxyrinchus*). The US Army Engineer Research and Development Center. ERDC/EL TR-14-12. 42 pp.

Rice, K. C., B. Hong, and J. Shen. 2012. Assessment of salinity intrusion in the James and Chickahominy Rivers as a result of simulated sea-level rise in Chesapeake Bay, East Coast, USA. Journal of Environmental Management, 111, 61-69.

Richardson, B. and D. Secor. 2016. Assessment of critical habitats for recovering the Chesapeake Bay Atlantic sturgeon distinct population segment. Final Report. Section 6 Species Recovery Grants Program Award Number: NA13NMF4720042.

Richardson, B. and D. Secor. 2017. Assess threats to the reproduction by Atlantic sturgeon through studies on spawning habitats of Chesapeake Bay DPS sturgeon in the Nanticoke estuary. Progress Report. Section 6 Species Recovery Grants Program Award Number: NA15NMF4720017.

Ryder, J. A. 1890. *The sturgeons and sturgeon industries of the eastern coast of the United States: with an account of experiments bearing upon sturgeon culture*. US Government Printing Office.

Sapp, A. 2010. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, Georgia.

Scott, W. B., and M. C. Scott. 1988. Atlantic fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Science No. 219. pp. 68-71.

Secor, D.H., E.J. Niklitschek, J.T. Stevenson, T.E. Gunderson, S.P. Minkkinen, B. Richardson, B. Florence, M. Mangold, J. Skjeveland, A. Henderson-Arzapalo. 2000. Dispersal and growth of yearling Atlantic sturgeon, *Acipenser oxyrinchus* released into Chesapeake Bay. Fishery Bulletin 98(4):800-810.

Shortnose Sturgeon Status Review Team (SSSRT). 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.

Smith, T.I.J. and J.P. Clugston. 1997. Status and management of Atlantic sturgeon, *Acipenser oxyrinchus*, in North America. Environmental Biology of Fishes 48:335-346.

Smith, T.I.J., D.E. Marchette and R.A. Smiley. 1982. Life history, ecology, culture and management of Atlantic sturgeon, *Acipenser oxyrhynchus oxyrhynchus*, Mitchill, in South Carolina. South Carolina Wildlife Marine Resources. Resources Department, Final Report to U.S. Fish and Wildlife Service Project AFS-9. 75 pp.

Stein, A.B., K.D. Friedland, and M. Sutherland. 2004. Atlantic sturgeon marine distribution and habitat use along the Northeastern coast of the United States. Transactions of the American Fisheries Society 133:527–537.

Sun, H., P.W. Benzie, N. Burns, D.C. Hendry, M.A. Player, and J. Watson. 2008. Underwater digital holography for studies of marine plankton. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366(1871): 1789-1806.

Sweka, J.A., J. Mohler, and M. J. Millard, T. Kehler, A. Kahnle, K. Hattala, G. Kenney, and A. Higgs. 2007. Juvenile Atlantic sturgeon habitat use in Newburgh and Haverstraw Bays of the Hudson River: Implications for population monitoring. North American Journal of Fisheries Management 27:1058–1067.

Taylor A.D., K. Ohashi, J. Sheng, and M.K. Litvak. 2016. Oceanic distribution, behaviour, and a winter aggregation area of adult Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, in the Bay of Fundy, Canada. PLoS ONE 11(4): e0152470. doi:10.1371/journal.pone.0152470.

Van Eenennaam, J.P., and S.I. Doroshov. 1998. Effects of age and body size on gonadal development of Atlantic sturgeon. Journal of Fish Biology 53:624-637.

Van Eenennaam, J.P., S.I. Doroshov, G.P. Moberg, J.G. Watson, D.S. Moore and J. Linares. 1996. Reproductive conditions of the Atlantic sturgeon (Acipenser oxyrhynchus) in the Hudson River. Estuaries 19: 769-777.

VDEQ (Virginia Department of Environmental Policy). 2020. Draft 2020 305(b)/303(d) Water Quality Assessment Integrated Report. Available online at https://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2020305(b)303(d)IntegratedReport.aspx.

VEPCO (Virginia Electric and Power Company). 2000. Section 316(a) Demonstration. VPDES Permit Number VA0004146 - Chesterfield Power Station. Virginia Electric and Power Company, Environmental Policy and Compliance, Glen Allen, Virginia.

Waldman, J.R., T. King, T. Savoy, L. Maceda, C. Grunwald, and I. Wirgin. 2013. Stock origins of subadult and adult Atlantic sturgeon, *Acipenser oxyrinchus*, in a non-natal estuary, Long Island Sound. Estuaries and Coasts 36:257–267.

Winger, P.V., P.J. Lasier, D.H. White, J.T. Seginak, 2000. Effects of contaminants in dredge material from the lower Savannah River. Archives of Environmental Contamination and Toxicology 38:128-136.

Wippelhauser, G.S., J. Sulikowski, G.B. Zydlewski, M. A. Altenritter, M. Kieffer, and M.T. Kinnison. 2017. Movements of Atlantic sturgeon of the Gulf of Maine inside and outside of the geographically defined distinct population segment. Marine and Coastal Fisheries, 9(1): 93-107.

Wirgin, I. and T. King. 2011. Mixed Stock Analysis of Atlantic sturgeon from coastal locales and a non-spawning river. Presented at February 2011 Atlantic and shortnose sturgeon workshop.

Wirgin, I., L. Maceda, J.R. Waldman, S. Wehrell, M. Dadswell, and T. King. 2012. Stock Origin of Migratory Atlantic Sturgeon in Minas Basin, Inner Bay of Fundy, Canada, Determined by Microsatellite and Mitochondrial DNA Analyses. Transactions of the American Fisheries Society 141(5):1389-1398.

Wirgin, I., M.W. Breece, D.A. Fox, L. Maceda, K.W. Wark, and T. King. 2015. Origin of Atlantic sturgeon collected off the Delaware coast during spring months. North American Journal of Fisheries Management 35(1):20-30.

Young, J.R., T.B. Hoff, W.P. Dey, and J.G, Hoff. 1988. Management recommendations for a Hudson River Atlantic sturgeon fishery based on an age-structured population model. pp. 353-365. In C.L. Smith, (editor) Fisheries Research in the Hudson River. State University of New York Press. Albany.

Ziegeweid, J.R., C.A. Jennings, and D.L. Peterson. 2008a. Thermal maxima for juvenile shortnose sturgeon acclimated to different temperatures. Environmental Biology of Fish 3: 299-307.

Ziegeweid, J.R., C.A. Jennings, D.L. Peterson and M.C. Black. 2008b. Effects of salinity, temperature, and weight on the survival of young-of-year shortnose sturgeon. Transactions of the American Fisheries Society 137:1490-1499.

APPENDIX A

STURGEON DATA COLLECTION FORM

REPORTER'S CONTACT INFORMATION

Name: First ____________ Last ____________

Agency Affiliation ____________ Email ____________

Address ____________

____

Area code/Phone number ____________

UNIQUE IDENTIFIER (Assigned by NMFS)

DATE REPORTED:

Month ☐☐ Day ☐☐ Year 20☐☐

DATE EXAMINED:

Month ☐☐ Day ☐☐ Year 20☐☐

SPECIES: (check one)

☐ shortnose sturgeon
☐ Atlantic sturgeon
☐ Unidentified *Acipenser* species

Check "Unidentified" if uncertain .

See reverse side of this form for aid in identification.

LOCATION FOUND: ☐ Offshore (Atlantic or Gulf beach) ☐ Inshore (bay, river, sound, inlet, etc)

River/Body of Water ____________ City ____________ State ____

Descriptive location (be specific) ____________

____

____

Latitude ____________ N (Dec. Degrees) Longitude ____________ W (Dec. Degrees)

CARCASS CONDITION at time examined: (check one)

☐ 1 = Fresh dead
☐ 2 = Moderately decomposed
☐ 3 = Severely decomposed
☐ 4 = Dried carcass
☐ 5 = Skeletal, scutes & cartilage

SEX:

☐ Undetermined
☐ Female ☐ Male

How was sex determined?

☐ Necropsy
☐ Eggs/milt present when pressed
☐ Borescope

MEASUREMENTS: Circle unit

Fork length ________ cm / in

Total length ________ cm / in

Length ☐ actual ☐ estimate

Mouth width (inside lips, see reverse side) ________ cm / in

Interorbital width (see reverse side) ________ cm / in

Weight ☐ actual ☐ estimate ________ kg / lb

TAGS PRESENT? Examined for external tags including fin clips? ☐ **Yes** ☐ **No** **Scanned for PIT tags?** ☐ **Yes** ☐ **No**

Tag #	Tag Type	Location of tag on carcass
____________	____________	____________
____________	____________	____________

CARCASS DISPOSITION: (check one or more)

☐ 1 = Left where found
☐ 2 = Buried
☐ 3 = Collected for necropsy/salvage
☐ 4 = Frozen for later examination
☐ 5 = Other (describe) ____________

Carcass Necropsied?

☐ Yes ☐ No

Date Necropsied: ____________

Necropsy Lead:

____

PHOTODOCUMENTATION:

Photos/vide taken? ☐ Yes ☐ No

Disposition of Photos/Video: ____________

____

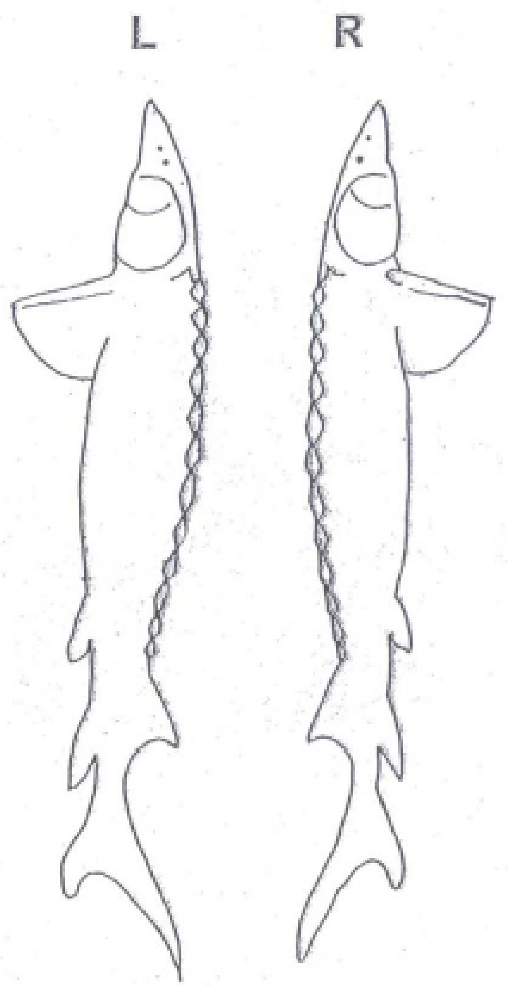
____

SAMPLES COLLECTED? ☐ **Yes** ☐ **No**

Sample	How preserved	Disposition (person, affiliation, use)
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

Comments:

Draw wounds, abnormalities, tag locations on diagram and briefly describe below



Describe any wounds / abnormalities (note tar or oil, gear or debris entanglement, propeller damage, etc.). **Please note if no wounds / abnormalities are found.**

____

____

____

____

____

Submit completed forms (within 7 days of observation of fish): by email to Incidental.Take@noaa.gov or by fax (978-281-9394). Questions can be directed to NMFS Protected Resources Division at 978-281-9328.

Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service (NOAA Fisheries) on this form will be released to the requestor provided that the requestor credit the collector of the information and NOAA Fisheries. NOAA Fisheries will notify the collector that these data have been requested and the intent of their use.